THE

POPULAR SCIENCE MONTHLY.

NOVEMBER, 1874.

THE NATURAL HISTORY OF THE OYSTER.

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I.

AN illiterate fisherman once became wellnigh eloquent in his effort to describe to us the treasures which the waters offered freely to man. Nature is, indeed, lavishly opulent. Among the food-treasures of this bounteous harvest of the sea, the oyster ranks high in the general esteem. And deservedly so, for she is truly the queen of the bivalves. Let us try to tell the story of her life.

Oyster-Planting.—For a creature of such lowly rank in the scale of animate being, it is wonderful what a literature attaches to the oyster. Through the roll of the ages it has been a factor of prime importance in the convivial instincts, the moralities, and the industries of men. It has honorable mention in classic song and story. When imperial Rome had her many million populace, and her almost fabulous wealth, the oyster figured prominently in the more than lavish luxury of that extravagant city. Do our oyster-growers know how ancient their calling is? About 2,400 years ago one Sergius Orata, a man of a practical mind, turned Lake Avernus into an oyster-bed; and through his culture of this bivalve the Lucrin oysters, as they were called, became in reputation the "Saddle-Rocks" of Rome. And what a splendid market he had! His practical genius carried the new industry of oyster-planting to great perfection; and such was his reputation in that line that the Romans had a saying that, should the oysters stop growing in Lucrin Lake, Sergius would make them grow on the tops of the houses. Avernus has at last succumbed to the mutations of time, and is to-day a miserable hole of volcanic mud. It now offers a good opportunity to test the great man's abilities; but Sergius Orata himself "dried up" some time ago.

Near Baiæ and Cumæ is the Neapolitan Lake Fusaro (Fig. 1). This was the classic Acheron. It is about three leagues round, and is hardly

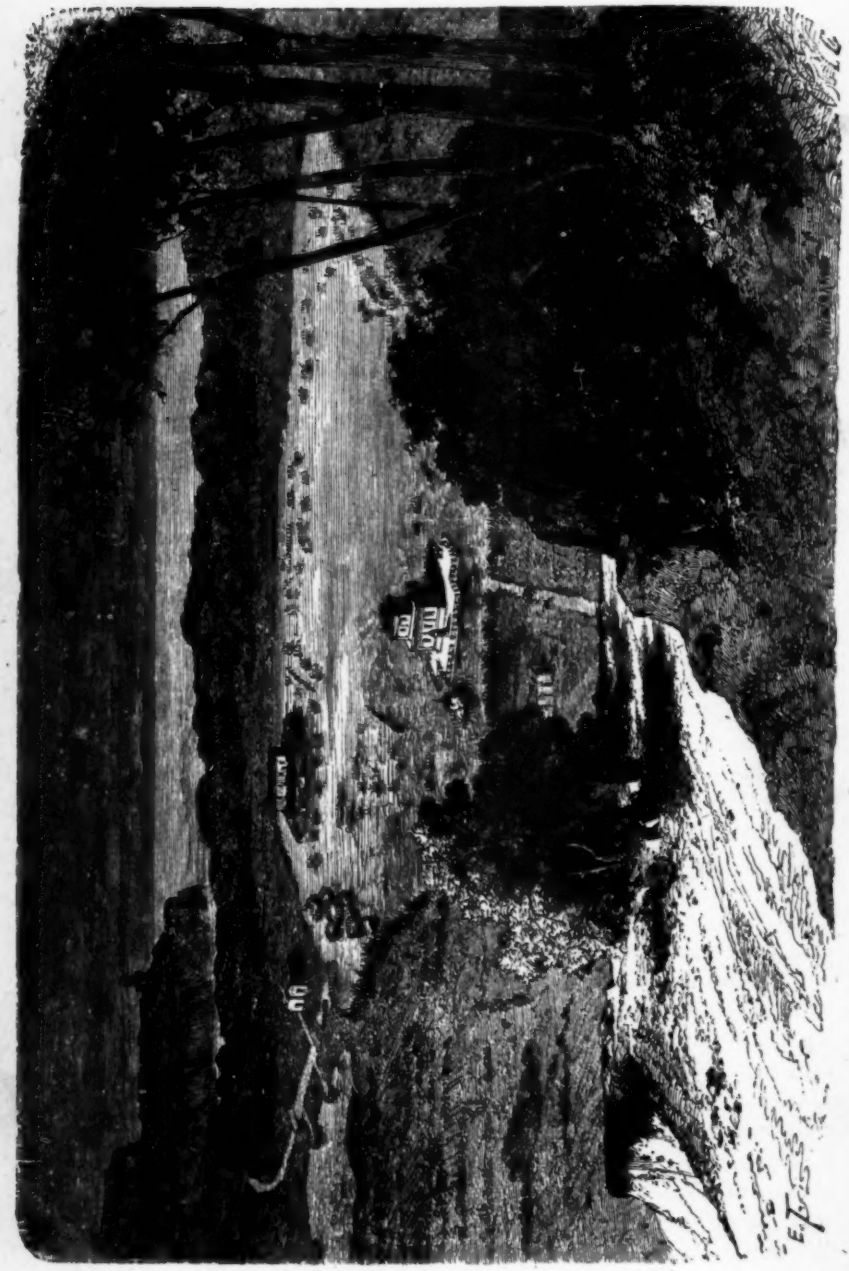

FIG. 1.—LAKE FUSARO AND ITS OYSTER-PLANTATIONS.

in any part more than six feet deep. Its bed is a black volcanic slime, such as one might suppose would be death to mollusks generally. From time beyond memory this has been an oyster park or plantation; a place for raising the young oysters, that is, the oyster-seed—namely, the small oysters, which, when put in proper places, will become oysters of an eatable size. For these young to settle on, heaps of stone are placed in the lake with a circle of piles round each heap (Fig. 3). In other parts of the lake the piles are driven in rows and connected by ropes, from which hang fagots, on which also the young can fix themselves (Fig. 4). These fagots, at the proper time, are easily pulled up, and the young, or "seed," picked off by hand to be planted elsewhere.

Formerly France possessed a great abundance of native oysters. But this industry was without regulation, and the French natives, like our Northern natives, came near being exterminated. A few years ago Prof. Coste, of the French Academy, called attention to the fact that the French oyster was becoming extinct. He took up the study of this mollusk in earnest, and learned many important facts concerning its nature. He even went to the Neapolitan oyster-park, and observed how the fishermen there saved the young ones. He then appealed to the government, which put means in his way for experimenting, and, in a short time, he had a successful oyster-plantation under way. It is in France as elsewhere, "seeing is believing," and "there is nothing that succeeds like success." Under the wise direction of this learned naturalist the new industry, oyster-planting, became a furor in France. "In two years 1,200 capitalists, associated with a similar number of fishermen, occupied a surface of 988 acres." By which is meant the area of shore-line exposed at low tide. And what labor! so thorough and scientific. The isle of Ré, with its unsuitable, muddy shores, had all that sea-bottom altered. In two years twelve miles of sea-coast thus changed was planted, with 1,200 parks in operation, and thousands more projected. Now, oyster-culture is conducted in France on better principles than anywhere else. And all of this great additional wealth to the nation comes out of the applied science of a man "that studied shells and worms," as is often said in derision. In France scrupulous provision is made for husbanding the fry. In America no effort is made in this direction, and the time is not far off when the nation will wake up to a serious calamity in this respect.

The American practice is simply this: In the spring of the year large numbers of sloops and schooners go south to procure the young oysters called "seed." This sets considerable money afloat southward, as they have to take with them the ready cash. In the days of "wild-cat" banking, the Southrons would take nothing but specie, and that must be paid just so soon as the oysters were put into the boat. The "seed" is obtained chiefly in the Rappahannock, the Nan-

ticoke, and a few other places. Oysters also of a moderate size are often brought north and laid down for a season, that they may increase in size and acquire something of the flavor of the Northern native, so superior to that of the Southern. The better kinds of the Southern, such as the Lynn Haven Bays, Sandy Points, Cherrystones, York Rivers, etc., are sent for immediate consumption to Baltimore, Washington, Philadelphia, and some to New York. New Jersey,

FIG. 2.—EUROPEAN OYSTERS: FIVE GROUPS OF DIFFERENT AGES GROWING ON A STICK OF WOOD.

New York, and Connecticut, are the favorite planting-grounds. When the vessels return with the young oysters they are planted, that is, scattered over the beds. As the lower side of the oyster is the heavier, this generally secures its falling right side up. The seed, or young oyster, is allowed to lie for from one to two years, seldom three, when it is considered ready for market, and in that time it has

greatly improved in quality. Early in the fall the work of taking up the crop begins. This is done by what is called tonging. An instrument is used called oyster-tongs. Something of an idea of it may be got by supposing two garden-rakes with very long handles, with the tooth-side of each rake facing each other; let the handles be secured by a loose rivet about two or three feet from the teeth, so that by operating the extreme ends of the handles the whole contrivance shall act as a pair of tongs. Working over the side of his boat, the oysterman and his comrade thus take up the first of the harvest. After tonging,

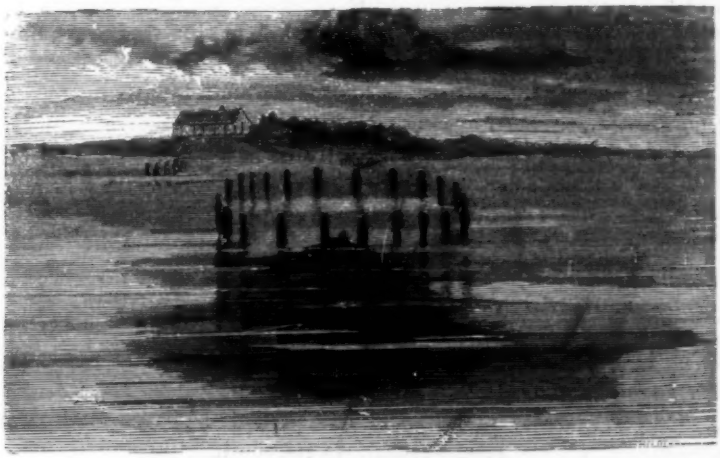

FIG. 3.—ARTIFICIAL OYSTER-BANK IN LAKE FUSARO.

the bed is again gone over, but this time with the dredge (Fig. 5). In this process a vessel with sails must be used (Fig. 6). The great iron bag or dredge is cast into the water and dragged along the bottom. Then (and terrible hard work this is) it is drawn up, and its contents are emptied on deck. Whether tonging or dredging, oystering requires broad-chested men, with sturdy hands and arms. The oysters are next taken a little way up a fresh-water creek or stream, into which they are thrown "to get a drink." The process sweetens and cleanses them. One day, often even one tide, is enough for this purpose. As the water is not deep, the mollusks are taken up with large forks. The workmen stand in the stream, wearing very high rubber boots. When late in the fall, this is intensely cold work. Before being thrown into the fresh water, a sorting process is gone through. There are dead oysters, and winkles, and conchs, and stones, and many useless matters, to be separated. All this is thrown upon the banks of the stream. After being taken out of the stream, before they can be sent to the great city, comes the process called "culling," that is, assorting into the sizes known in the trade. The smallest are called

"culls," and are sold by the bushel. These are used in making the popular "stews" of the saloons; also, when opened, it is this sort that is sold by the quart for domestic use. The others are known as "count," and the restaurants serve them up as "fries," and on the half-shell, as raw. These are sold by the hundred.

After the harvest is finished, not a few oysters will yet remain on the beds. The grounds are then given up to the laborers who have worked them on hire. Under a new impulse these men go over the grounds again with tongs and dredge. They work on shares usually, returning to the owner of the beds one-half of the results, which makes a really handsome thing for the gleaners, whose work in this way lasts from two to three weeks, making three or four days a week, each man often clearing as his portion from four to five dollars a day. At any rate, such generally is the practice with its results at Keyport, N. J., where for many years the principle of the good old biblical rule, of not forgetting the gleaners, is almost religiously observed in the last gathering of this harvest of the sea.

Local Varieties.—It is generally conceded that the Northern oyster is superior to the Southern. Upon this understanding, and the fact that formerly the Southern oysters that were brought north were chiefly procured from Chesapeake Bay, and the favorite Northern natives were got around and near New York, the old oystermen used to speak in general terms of two kinds, the Southern and the Northern, which they designated as "Chesapeakes" and "York Bays." There are, however, a great many local names, which are supposed to indicate special excellences. All these northern edible oysters are of one species, *Ostrea borealis*. Some naturalists, however, claim that the Southern is different, and should be called *Ostrea Virginiana*. But for the plain reason that both varieties can any day be found in any oyster-bed in Long Island Sound, and indeed they seem to change by growth indiscriminately into each, a more rigid science would refer them all to the name given by Lister—*Ostrea Virginiana*. Yet, take them in the mass, and any experienced oysterman will tell the Southern from the Northern. The European oyster is called *Ostrea edulis;* but that it is sufficiently different to make a distinct species is far from certain. Experienced dealers will pick out the local varieties of the Northern article. Of these we have many names—such as the Keyport, City Island, Guilford, Blue Point, Rockaway, Saddle-Rock, Shrewsbury, etc. The Blue Point was for fifty years "the Knickerbocker among oysters." It was raised chiefly in Great South Bay. This fine oyster had to yield on the appearance of the splendid Saddle-Rocks. This name is still given to all very large oysters, and generally to those taken in the East River. It is, however, no longer in existence. They were first brought to Fulton Market, New York, by an old negro named Henry Scott. The following, by our friend Dr. O. R. Willis, is authentic. It appeared in the *New York Observer:*

"The original Saddle-Rock oyster was not only very large, but possessed a peculiar, delicious flavor, which gave it its reputation. And it received its name because it was discovered near a rock known as Saddle-Rock. A high northwest wind, continued for several successive days, always causes very low tides in Long Island Sound and its bays. On the farm of David Allen, situated near the head of Great Neck, on the eastern shore of Little Neck Bay, is a rock about twenty feet high, and from fifteen to twenty feet in diameter. The shape of the top of this rock resembles somewhat the form of a saddle, and from that circumstance is called Saddle-Rock. At low water the upper or land side of this rock is left bare, while the opposite or lower side is in the water. In the autumn of 1827, after a strong northwest wind had been blowing for three days, a very low tide occurred, and the water retreated far below the rock, leaving a space wide enough for a team of oxen to pass quite around it. This extraordinary low tide revealed a bed of oysters just below the rock. The oysters were very large, and possessed the most delicate flavor;

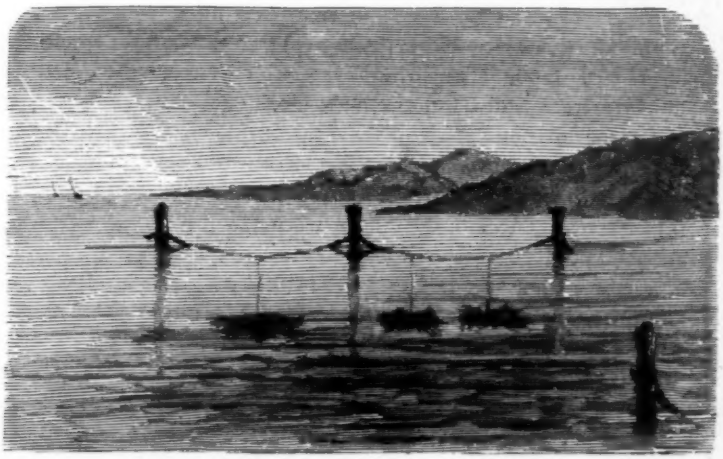

FIG. 4.—FAGOTS SUSPENDED FROM ROPES, TO SERVE AS ATTACHMENTS FOR OYSTER-SPAT, IN LAKE FUSARO.

we collected cart-loads of them, and placed them in our mill-pond (tide-mill). The news of the discovery spread among the oystermen, and boat-loads soon found their way to the city, where, on account of their excellent flavor, they commanded fancy prices, even reaching ten dollars a hundred!—an enormous price for those days. In a very short time the locality was exhausted, and for more than forty years there has not been a real Saddle-Rock oyster in the market."

At present the favorite native is the Shrewsbury, which is mainly obtained by planting, in the Shrewsbury River, seed procured from Tappan Bay. Of this seed there will be in a bushel about 2,500

young oysters, costing about 60 cents. After two years' growth, 200 will fill that measure. At present the Shrewsbury is accounted by many as the emperor of the bivalves, and will fetch in market at wholesale from $1.50 to $3.50 a hundred. What is called the summer oyster is brought from the York and James Rivers, Va., and planted north late in the season for summer use.[1] Some are brought from the waters of Maryland.

THE OYSTER-TRADE.—Dragon, as it used to be called, Fair Haven now, near New Haven, was formerly *the* place where oysters were put up for Northern and Western use. The bivalves were opened and put into neat little kegs. Latterly the business has gone down to Baltimore. "Shipping is yearly becoming more extensive, and Baltimore —though ahead at present—has a powerful rival in the metropolis, as all roads lead to it, like those of the ancient world to Rome. In October the shipping to Europe and California commences, and latterly tubs instead of sealed cans are used. In shipping to St. Louis, Cincinnati, and other places within a distance of a thousand miles, oysters are shipped in cold weather in kegs protected by gunny-bags, but in summer the kegs are placed in larger vessels and the space packed with ice and sawdust. So expert has experience rendered the shipper that oysters seldom spoil, and the Western purchaser may rejoice in a comparatively fresh and wholesome article."

Even in the northern parts of the State of New York, thirty years ago, oysters were an unknown luxury. But the rapid transit "which has been developed in the last quarter of a century has given a great impulse to exportation, and statistics from reliable sources show that many millions of dollars' worth of oysters are yearly sent from this port alone. For instance, the average retail trade per week of Fulton Market requires 250,000 oysters, and one establishment is called upon to supply from 1,000 to 1,500 customers daily. The wholesale department packs and exports 100,000 weekly, and gives employment to a large number of men.

"The yearly returns from the home-market amount to $4,000,000 per annum, and from other localities to about $1,000,000. The trade gives employment to 2,500 men in New York City, and to 200 in Brooklyn. There are 750 oyster-saloons in the metropolis, and 100 in the City of Churches. On the North and East Rivers about 50 scows are employed receiving oysters from the vessels arriving from these various bays, and from these boats about 3,000,000 oysters are daily shipped throughout the country. Five hundred sailing-vessels are employed in this vicinity, which number includes every thing from a sail-boat to a schooner of 150 tons. A corps of 5,000 men is engaged in planting and bringing to market, who earn on an average from three

[1] For some of the facts cited above, and in a few paragraphs immediately following, I am indebted to an able article in the *Brooklyn Eagle*, the date of which I cannot tell.—S. L.

to four dollars per day. In fact, it may be safely estimated that about 10,000 men, directly or indirectly, make a living in the oyster-trade of the two cities. Many of the ancestors of the wealthiest Knickerbocker families were oystermen, and at the present day many a bluff, rugged-looking man engaged in this business has a bank account that more pretentious people, living in a brown-stone house, might well envy."

American oysters are now being shipped to Europe by steamer. The first ventures proved disastrous. They were shipped in bulk in the vessel's hold. They "spoiled," that is, perished, doubtless from the warmth and want of air, as oysters are often carried by sail-vessels from the South to the North safely, although they may be longer on the way than the steamer, and even carry larger quantities in bulk. These vessels employed by the oystermen carry, according to the vessel's capacity, from 1,800 to 2,800 tubs, a tub being a bushel and a half. But, though oysters were at first lost in their transit by steamer, they now go more safely, being put up in barrels, instead of in bulk. And this business of oyster transportation is destined to assume immense proportions; hence the following from the *World* of December 22, 1873, may become an item in history: "N. B. Mulliner, A. W. Mead, Oliver Charlick, and Miles Smith have formed a company for the shipment of oysters to the London market, and made their first consignment during the past week from Freeport. It is proposed to sell the oysters on commission."

An experiment, the results of which, if successful, will be followed by great consequences, is a recent attempt made to acclimatize the New Jersey oyster in California. Joseph Ellsworth, a heavy operator in this bivalve, who owns one of those floating establishments known as scows, affairs of immensely greater importance than the name would imply, made a very interesting venture last fall. He freighted a car with the "seed" for San Francisco. The seed was obtained in Newark Bay, and 60 cents per bushel were given for it in the rough, that is, as it adhered to shells, etc. The best and cleanest were selected, averaging in size about that of the old copper cent. The cost of this seed would be about $8 per bushel at its delivery in San Francisco. It is estimated that two years' growth will suffice for this market, where they will be more easily suited on the question of size than the people East. It is also expected that, after the spawning-season is safely passed over, enough stock, or seed, will be had to make future operations successful. Of course, the whole matter is, as yet, an experiment. The native Californian oyster is a puny affair, and it is to be feared that the Eastern oyster will degenerate in Pacific waters. We shall see. Meanwhile the experimenter deserves great praise for the energy shown in his bold venture.

THE RISKS.—It will be news to many to hear that the business of the oyster-producer is one of great risk. All is not gain to these industrious people, for often capital is sunk in the waters that is never

taken up. Many years ago we remember the then small village of Keyport suffering a loss in one season of $50,000. Even a severe storm continued unusually long has smothered the beds by agitation of the mud, for the oyster must keep its nib out of the bottom. But two seasons ago, in one of the branches of Shrewsbury River, a crop was almost entirely lost, the supposition being that it was poisoned by the washing from a new turnpike, in the construction of which a peculiar ferruginous earth had been used. Formerly the oyster throve as a native as high up the North River as Peekskill, and probably its limit was not below fifty miles from the mouth of the river. They are now, however, exceedingly scarce, even as high as Croton. The belief exists that the railroad has destroyed them by the washing from the necessary working of the road, which is constantly finding its way to the river-bed. So long ago as 1851, Colonel John P. Cruger, of Cruger's Landing, a very intelligent observer, called our attention to the fact of the mischief thus done.

And there are meteoric causes which affect the oyster. We have known an unusually severe winter to kill the bivalves in great numbers. And even the seed in its transport from Virginia has been destroyed—whole valuable cargoes—by foggy weather, and adverse winds. Moreover, as will be seen, the oyster has its deadly enemies in the animate ranks.

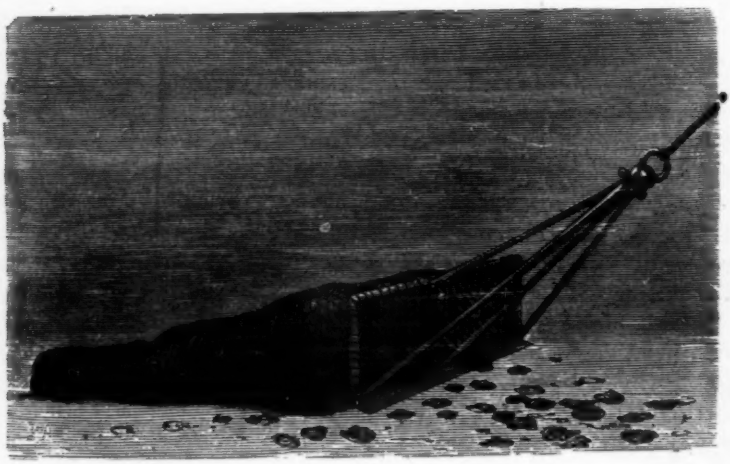

FIG. 5.—AN OYSTER-DREDGE AT WORK.

THE PHYSIOLOGY OF THE OYSTER.—By persons engaged in the business, we have been asked, "Are there hes and shes among the oysters?" The answer of the naturalist would be, "There are not." Low down in the scale of life many animals on their sexual side are singularly suggestive of plants. Take, for example, that splendid grass, *Zea mays*—Indian-corn. On the top of this graceful plant is a

large, brush-like panicle. This contains the staminate or male flowers. Embedded in the green cob of the ear are the pistillate or female flowers. Their pistils make the tassel, which is called "the silk." Upon these falls the fertilizing pollen of the stamens from the raceme above. Without this contact there would be no kernels on the cob. In some plants this bisexuality occurs in the same flower. A notable instance is that of the prolific strawberry known as Wilson's Albany Seedling. A similar fact, certainly an analogous one, is true of the oyster. It is bisexual. It is not masculine alone, nor feminine alone, but both; and perhaps might be defined by that innovation in modern grammar, as of "the common gender." It is hermaphroditic.

The question of the parental relation of the young oyster on its paternal side is most certainly a very perplexing one; for, albeit no matrimonial dereliction was ever known among these Ostreæ, yet the fact remains that no oyster was ever begotten that knew its own father.

If, now, the reader will take a little pains to compare our description of the organism of the oyster with Fig. 7, he will see that, however lowly the oyster may be regarded, it has a compact and even a complex anatomical structure, manifestly a beautiful adaptation to the creature's necessities; and even exhibiting, in a very instructive manner, a wonderful likeness to our own organization. If this seems a startling position, let the reader follow the discussion, and see if it be not made good. If we take an oyster in the hand, it will be observed that, of the two valves or shells, one is much deeper and heavier than the other. This is the bottom or lower valve, because, when lying undisturbed on the bed of the water, it is the under side. The upper valve is often a mere thin plate of shell. It is observable, too, that generally the lower valve is, on the outside, quite convex, while the upper one is usually either flat or a little concave. Let it now be remembered that, anatomically, an oyster has also two sides, and that while living its normal position is to lie on its left side. The valve, then, represented by the cut, is the lower or deep valve, in popular speech, but in scientific phrase it is the left valve. The oyster itself is shown as representing what is popularly known as its upper side, the side seen when eaten on "the half-shell;" correctly speaking, it is the right side of the animal.

Let us now follow the index-words of the figure. We find a thin sheet of flesh lying on the shell. It is the left mantle, for there are two, one to cover the right side also, so that both together are continuous as one, and with it the animal inwraps itself.

The figure shows a portion of the right or upper lobe of the mantle. It is sometimes called the pallium, and really is the oyster's cloak, though it is always and only worn in the house. This is not true, however, of all the mollusca. The beautiful cowries, so high colored and bright, are exceptions. If you examine a common tiger

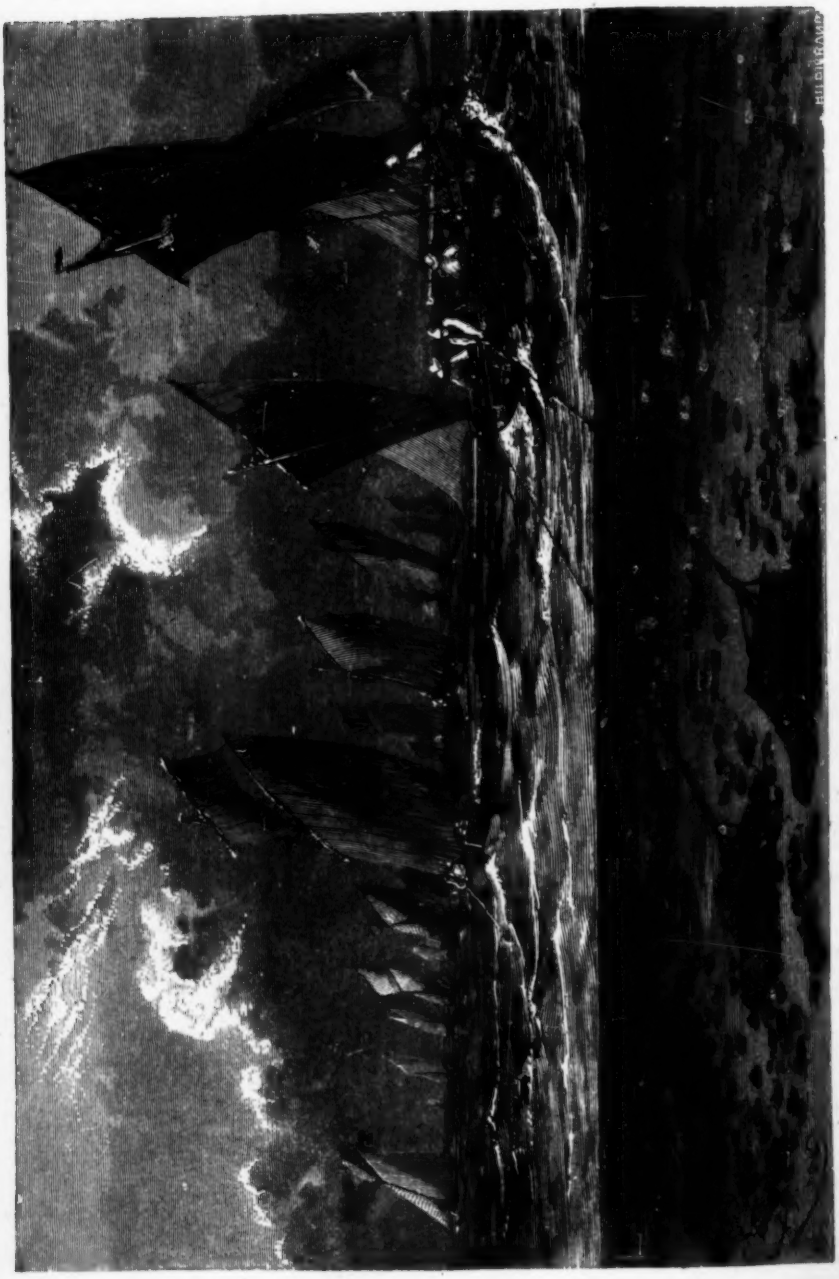

FIG. 6.—VESSELS DREDGING FOR OYSTERS.

cowry or Cypræa, if an adult shell, you will find that, while the entire shell is covered with a shining enamel, there is along the whole length of the back of the shell "a line of pale color." The animal extends both folds of the mantle outside of itself and over the shell, and that line is where the lips of the folds meet. This mantle has much to do with obtaining food. The oyster opens its shells about a quarter of an inch apart. These membranes, that make the mantles from both sides of the animal, meet just at the opening of the shell. They are fringed at their edges with rows of tiny cilia, or soft fleshy hairs of extreme delicacy. This pallial fringe in an eminent degree serves the oyster as organs of touch. Probably this sense, though distributed somewhat over the entire surface of the body, is along this fringe exquisitely acute. The English call this fringe the oyster's beard. It is protruded just a little out of the shell; and these cilia, almost numberless, keeping up their rapid movements in the water, make as it were two parallel vibrating curves, which beget a sort of aquatic vacuum inside the shell, into which the water flows, as in a diminutive whirlpool. The stream thus affected brings with it the algæ spores and animalcules which constitute the oyster's food. But where is the oyster's mouth? Speaking popularly, it is away back near the hinge of the shell, as shown in the cut. To this point the current flows. Now, it must not be supposed that all is fish that comes to the oyster's net. Far from it. Hence this mollusk has eclectic functions. Doubtless a sharp spicule of a sponge may occasionally get into the mouth, even as a bone splinter can get by accident into a human throat. The word "tentacles," in the cut, refers to certain organs, that might be called labial or lip fingers. These, it will be noticed, have immediate relation to the mouth. They are the organs for discriminating food—functionally they are manipulating lips. The stomach is not shown in the cut, being overlaid by the other organs. The intestine, at least a part of it, is exposed, and its extremity is really the anus or vent. So much, then, is apparent, that the oyster possesses an alimentary system of some complexity.

A series of plates or plaited frills, lies on the mantle, if indeed it is not a specialized portion of that organ. These plaits are the branchiæ or gills. In the respiratory system of an oyster these branchiæ or gills are precisely the same to it as are the gills to a fish, or our lungs to us. Through these gills the water is passed. After imparting to the blood the oxygen taken from the air which the water contained, that water, now laden with carbonic-acid gas, is expelled at the respiratory aperture, or ex-current orifice, the dark spot in the figure immediately under the end of the intestine, which we have already said is the anus or vent, whence this refuse water, like a cleansing stream, passes directly out of the shell. This contrivance is certainly very beautiful. It is in fact a miniature sewer carrying off promptly and quickly the excrements as fast as they are made.

The heart, constricted at the middle like the former silk purses of the ladies, is shown in place. The constriction separates the auricle and the ventricle. And so even an oyster has three sets of circulating organs, the heart with its double set of functions, and the arteries and veins. And this little organ beats with regular pulsations. That little auricle receives the blood from the gills, and that tiny ventricle is the vital force-pump that propels it into the arteries. "From the capillary extremities of the arteries it collects again into the veins, circulates a second time through the respiratory organ, and returns to the heart as arterial blood." The color of the oyster's blood is a pale bluish white—in fact it may be called opaline. Our oyster, then, is not a heartless thing. If you open it with care and skill, as would the naturalist, you may see and count the throbbings of its tiny heart.

In its proper place is seen the liver, which is always a large organ in the mollusca, or so-called shell-fish. It is true that this organ in the oyster secretes bile, and doubtless in large quantities. It is not probable, however, that this organ, though large, ever performs a metaphorical function, for it is very doubtful whether the oyster ever gets up the amount of emotion necessary "to stir one's bile." To the fast liver this oyster-liver is every thing. The secret is just here: this secretion of the liver is the real appetizer of the feast. This oyster-bile is both gustatory and digestive. It excites the glands of the palate and the secretions of the stomach.

The part indicated by the word muscle is the portion through which the knife is passed when opening an oyster. In popular parlance it is sometimes called the "eye," and by some the "heart;" terms which, thus applied, are without meaning. It is the adductor muscle, and is the organ with which the oyster pulls-to its doors.

To sum up these considerations of the oyster's physiology, we see that, to the full extent of its necessities, it has distinctive sets of organs for the performance of the three classes of functions carried on in our own organization, namely, ingestion, respiration, and circulation.

THE OYSTER'S SHELL.—The toughest part of the oyster is the adductor muscle (Fig. 7). The office of this large, strong muscle is to pull-to and keep shut the great doors of the house. And a very curious bit of mechanism is subsidiary to this action. At the upper part of the cut is seen the hinge, a white spot with a dark curve below it. This dark curve is the hinge-ligament. It is a dark substance which fills up the pit or depression near the hinge. In the living animal it is wonderfully like gutta-percha—black, tough, and elastic. Let us attempt to explain its use to the oyster. Although this mollusk has a strong muscle with which to close its valves, it has not any with which to open them. Now, supposing we should take a lady's writing-desk, and, between the hinges at the back of the lids, should insert a piece of India-rubber, then should press down the lid, and turn the key; it is plain that the bolt of the lock now keeps the lid down, which could

not be done simply by the weight of the lid, as before. Now, if we unlock the desk, up springs the lid, raised by the expansive force of the rubber at the hinges. This is precisely one of the functions of the hinge-ligament of the oyster. When the animal desires to shut up the valves, it contracts the great adductor muscle. When it needs to open them, it relaxes that muscle, and the valves open of themselves. Patrick's mishap was not merely amusing, regarded as a blunder, but even more so when viewed in this physiological light. He was told to go into the cellar and bring up some oysters in the shell; and his mistress gave him a strict charge not to bring any that were dead.

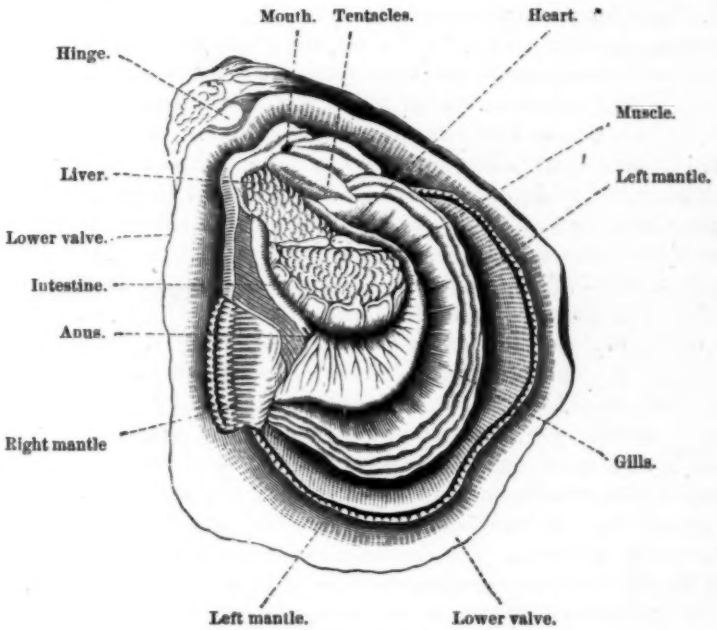

FIG. 7.—ORGANISM OF AN OYSTER.

Patrick brought up a tray full, and every bivalve upon it was gaping wide! In reply to the astonished look of his mistress he said: "Sure, mam, they must be alive, or how could they keep their mouths open?" "But, Patrick," urged the lady, "could you not tell the difference by the smell?" "And sure, mam, I was remarking that same to meself. But mightn't the others have bad breaths too, if they'd only open their mouths a bit?" Had the matter been pressed to an explanation, perhaps the mistress would have been as severely taxed as the servant to render a reason.

The growth of an oyster-shell is always at the edge. It is effected by the rim of the mantle, as a series of delicate tips assorting the lime which is held in solution in the sea-water, and most daintily laying in

its proper place the invisible cement. The precise method of the operation is not, I think, understood. It seems to me that the process is not a direct one, but rather the result of another process. All can recollect the once-popular mackintosh, a sort of water-proof cloak. It was little else than ordinary cloth, with an insoluble substance infused into the spaces between the fibres of the fabric. Is it not likely that the oyster has a process of its own not very dissimilar?—that it deposits a delicate net-work of animal substance as the staple, and that this is soon filled in with carbonate of lime, taken in mechanically from the salt-water? And this same organ has, along its edge, a series of pigment-cells, from which it exudes the paint that decorates the shell. In this respect the American oyster is a very plain affair. That of Europe has more color on the shell, I think, as it is more corrugated in form, and of less size. Our own oysters, we believe, both in quality and size, excel all others. (For a group of European oysters, of ages varying from that of three days to that of one year, *see* Fig. 2.)

If the shell of an adult oyster be examined, it will appear to be a series of shells, lying or lapping upon each other like tiles. There is, however, a difference. The lap of the upper one is not merely on the upper end of the lower one, but also on the middle, thus leaving a margin nearly all round. So the uppermost layer is always the smallest, and the lowermost one is always the largest of the series. The oystermen call these laps "shoots"—each one represents a season's growth. Thus each "shoot" shows the precise size of the oyster at a given year of its life, while the sum of the entire series gives the exact number of years the creature has lived. This shows how often the logic of Nature runs in parallel lines; for it brings up the old maxim again, "Every one to his own trade." The botanist counts the season-rings in the bole of a tree. The jockey tells the age of the horse by its teeth. The drover sets down the age of the cattle he buys by counting the rings on the horns; and in like manner the oysterman comes to a judgment by the number of "shoots" on the bivalve's shell. But all these specialists alike err when giving judgment upon an individual that has reached extreme old age.

The capability of the univalve mollusks to repair the shell when broken has been long known and understood by naturalists. In respect to the bivalves not so much is known. The oyster has some wonderful things in the way of repairing its house after being broken into. A case is known to us in which an oyster was so badly fractured at the nib that a piece of shell about an inch wide was broken off, and the poor animal protruded. An oysterman, for experiment's sake, restored it to the water, and, to be sure, put it close by a pole driven into the bed. This was in the spring. In September it was taken up and examined, when lo! the ingenious little builder had thoroughly repaired all damages!

THE NERVOUS SYSTEM OF AN OYSTER.—Physically unstrung, the

good old lady thus gave expression to her sufferings: "O doctor, I'm getting so terribly nervous! I wish to goodness I'd no nerves at all, like an oyster!" An animal without nerves! One must go down very low in the scale of living things to find a creature enjoying such a dubious felicity. The amœba—a simple, gliding clot or molecule of living jelly—enjoys this singular distinction. It has no nerves. And of old time some of the philosophers even entertained no higher conception of the organization of the oyster. Nor was it any better with Seneca, the moralist, who so eloquently urged the practice of self-denial, and ascetic severity, and whose practical knowledge of the bivalve extended to the personal consumption of just one hundred at a time. These learned men knew nothing about amœbas, or they would surely have leaped to the conclusion that an oyster was an amœboid animal shut up in a shell. Science, however, that sturdy non-respecter of persons, while it has pulled some things down, has lifted others up. Some of this exaltation has fallen to the oyster. Its nervous system is shown to be a very beautiful affair, and might be made the basis of some startling hypotheses in philosophy. It seems that, in common with the other learned men of his day, Plato regarded the oyster as the typical know-nothing of creation, and so, under the process known as transmigration, he judicially consigned the soul of the ignorant man at death to the occupancy of an oyster. Only to think of it! That last half-dozen fat mollusks one took so unsuspectingly down from the half-shell were possessed of an equal number of low, unlettered rapscallions in the spiritual state! You don't believe it? Of course. Who does? And it doth appear that Mr. Plato had but little to do when he was thus billeting bad company upon respectable people. Indeed, has he not much to answer for? A philosopher tempting to sin! Is not the man who stirs the pun as bad as the punster? Even at the risk of incurring punitive consequences, it must be said

That his metempsychosis
A contemptible joke is!—

a sentiment which, for want of prose, had to be thrown into rhyme. But it is urged in extenuation that this great man was only chaffing some old Greek who liked oysters, and that we ought to look rather to the wheat of his philosophy.

It is not intended here to go the length of declaring for the oyster that it has the feelings of a gentleman; although in Figuier the Scotch oyster-dredgers (Fig. 6) are represented as singing at their toilsome work:

"The herring it loves the merry moonlight,
The mackerel it loves the wind;
But the oyster it loves the dredger's song,
For it comes of a gentle kind!"

Let us look closely at Fig. 8, which represents the nervous system of an oyster. It is necessary, in the study of the nerves of the in-

vertebrate animals, to use the word *ganglion*, which means a knot of nerves. Really, it signifies a little brain, so that an insect or a mollusk may have several brains in different parts of its body. It should be remembered, also, that in anatomy the forward or anterior end of an oyster is the part containing the mouth, and that is up against the hinge, while the posterior part happens in this case to be near the opening, or, as the oystermen call it, the nib of the shell. At *b*, then, we see the large brain of the oyster called the posterior ganglion. We see, too, that it is surrounded by nerves running to other parts of the structure. There are two curved branches, marked *c c*, which connect this brain with two comb-like objects. These are the nerves of the branchiæ or gills. This brain, then, has direct control of the mechanism and functions of respiration. But it is noticeable that it is

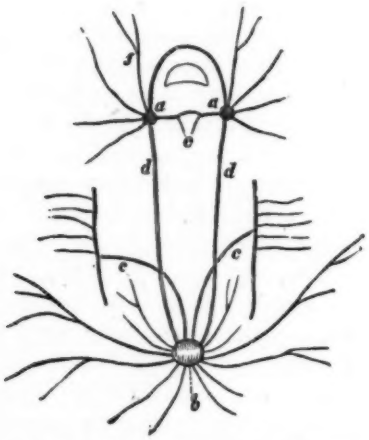

FIG. 8.—THE NERVOUS SYSTEM OF AN OYSTER.

also connected with the entire system of the two nerve-lines, *d d*, which suggest the spinal cord of the vertebrates. And this double nerve-line crosses the two ganglia or little brains, *a a*, which are connected by the transverse nerve-branch *e*; thus the mouth, whose place is shown by the half-moon, is encircled by a nerve-ring, and this regulates the functions of ingestion. In those mollusks which travel, as do mussels and scallops, there is a ganglion or locomotive centre. Bearing this in mind, and the fact that the oyster does not have this ganglion, because it does not need it, not being a traveler at all, let us give the gist of Dr. Todd's remarks on the nervous system of the mollusca in general: "It affords a beautiful example of the complete analysis of the more complicated nervous system of the vertebrata. Have we not here distinctly marked out the cerebrum (the centre of volition and sensation), the medulla oblongata (the respiratory centre), and the cerebellum (the locomotive centre), as they occur in the

higher vertebrata? And, in the aggregate of the chords by which the œsophageal ganglia communicate with the pedal and branchial ones, do we not see the analogue of at least a portion of the spinal cord, that portion which consists of afferent and efferent nerves to and from the brain?" It is plain, then, that, with a brain outfit of such a character and quantity, there must be something of a corresponding brain-force. In plain words, we mean that, possessing such a physiology, the oyster must sustain an analogous psychological relation. Organs imply functions. Pythagoras held that "animals have reason but no mind." Let us, then, see what sort of impressions an oyster can receive, and what kind of thinking it can do. If not too preposterous, we may even indicate its capacity to receive a modicum of education.

The adult oyster is eyeless, and of course blind. Yet it does without eyes that which we in its position could not do better with. It is affirmed that a bed of oysters has been seen to close by a precautionary impulse at the approach of a row-boat, even before the shadow of the approaching boat had reached them. Now, this is more than a blind man's distinguishing light from darkness. Is not that an exquisite sensitiveness which can thus note the faintest tint of shadow—the extremest margin of an oncoming obscuration?

Before the railroad days, our oyster-growers used early in the fall to canvass the villages on the Hudson River for orders, to be filled just before the river should be closed with ice. The meaning of this is that these men committed themselves to supply oysters in the shell, with the guarantee that the bivalves thus supplied should not die before their time came. The oysters were actually kept alive during the greater part of the long winter. The fat bivalves were handled with some care, and were spread on the cellar-floor, the round or lower side down, so as not to allow the liquor to escape. That such a life required a great change of capacity or habit in the bivalve is evident; and it needed a training, yes, an education, ere the oyster attained to such ability. And this was the way it was done: Beginning early in the fall, the cultivator of the oyster took up the fat bivalves from their bed where he had planted them, and laid them a little higher up on the shore, so that for a short time each day they were exposed out of the water. After a few days of this exposure by the retreating tide, they were moved a little higher still on the shore-line, which gave them a little longer exposure to the air at each low tide. And this process was continued, each remove resulting in a longer exposure. And with what results? Two very curious ones—inurement to exposure, and the inculcation of a provident habit of making preparation for the same. What! providence in an oyster? Yes, when he's educated. When accustomed to this treatment, ere the tide retires, the oyster takes a good full drink, and retains the same until the tide returns. Once, while waiting for the stage at a country hostelry, we overheard the following between two rustic practitioners

at the bar: "Come, Swill, let's take a drink!" "Well, I don't know. Ain't dry myself. Hows'ever, guess I will take a drink, for fear I *might* get dry!" With better philosophy on their side, these educated oysters, twice in every twenty-four hours took their precautionary drink. The French method of oyster-training is much more laborious. The adult bivalves are carefully spread out *in* the water, and periodical lessons are given to each one individually. Each oyster on this occasion receives a tap, not with a ferule, but with a small iron instrument. This causes the bivalve to close tightly. Finally the last day comes with its last premonitory tap. Its education thus finished, it takes passage with its fellow-graduates for Paris. As a result of its education, it knows how to keep its mouth shut when it enters society!

Said one of the English commissioners at the great World's Fair, in respect of the American inventions on exhibition, "They show so much knowingness!" So we think of this oyster-training; the American practice shows a common-sense tact, not found in the French method. And, though in a vastly more ancient sense, the secret of keeping oysters alive in the winter is an American art. Connected with the inland deposits of oyster-shells, made by the former Indian tribes in New Jersey, the writer has discovered what he believes to be oyster-preserves, the evidence of pits in which the Indians stored the living bivalves for winter consumption, when the bays and rivers of New Jersey were frozen over. While unearthing this Indian *cache*, the thought occurred, "How knowing these ancient people must have been!"

The next article will give, in detail, the friends and companions of the oyster; its enemies, with their modes of attack, and the geographical area of this bivalve.

HERBERT SPENCER AND THE DOCTRINE OF EVOLUTION.[1]

THE change that has taken place in the world of thought within our own time, regarding the doctrine of Evolution, is something quite unprecedented in the history of progressive ideas. Twenty years ago that doctrine was almost universally scouted as a groundless and absurd speculation; now, it is admitted as an established principle by many of the ablest men of science, and is almost universally conceded to have a basis of truth, whatever form it may ultimately take. It is, moreover, beginning to exert a powerful influence in the investigation

[1] A Lecture delivered before the New York Liberal Club, June 5th, 1874, by E. L. Youmans.

of and mode of considering many subjects; while those who avow their belief in it are no longer pointed at as graceless reprobates or incorrigible fools.

With this general reversal of judgment regarding the doctrine, and from the prominence it has assumed as a matter of public criticism and discussion, there is naturally an increasing interest in the question of its origin and authorship; and also, as we might expect, a good deal of misapprehension about it. The name of Herbert Spencer has been long associated, in the public mind, with the idea of Evolution. And, while that idea was passing through what may be called its stage of execration, there was no hesitancy in according to him all the infamy of its paternity; but, when the infamy is to be changed to honor, by a kind of perverse consistency of injustice, there turns out to be a good deal less alacrity in making the revised award. That the system of doctrine put forth by Mr. Spencer would meet with strong opposition was inevitable. Representing the most advanced opinions, and disturbing widely-cherished beliefs at many points, it was natural that it should be strenuously resisted and unsparingly criticised. Nor is this to be regretted, as it is by conflict that truth is elicited; and those, who, after candid examination, hold his teachings to be erroneous and injurious, are certainly justified in condemning them. With such, at the present time, I have no controversy, but propose to deal with quite another class of critics. There are men of eminence, leaders of opinion, who neither know nor care much for what Mr. Spencer thinks or has done, but are quite ready with their verdicts about him; and, so long as it is not generally known to what an extent we are indebted to him for having originated and elaborated the greatest doctrine of the age, these superficial and careless deliverances from conspicuous men become very misleading and injurious. By many he is regarded as only a clever and versatile essayist, ambitious of writing upon every thing, and who has done something to popularize the views of Mr. Darwin and other scientists. For example, M. Taine, in a late Paris journal, says: "Mr. Spencer possesses the rare merit of having extended to the sum of phenomena—to the whole history of Nature and of mind—the two master-thoughts which, for the past thirty years, have been giving new form to the positive sciences; the one being Mayer and Joule's Conservation of Energy, the other Darwin's Natural Selection." Colonel Higginson says:[1] "Mr. Spencer has what Talleyrand calls the weakness of omniscience, and must write not alone on astronomy, metaphysics, and banking, but also on music, on dancing, on style." And again: "It seems rather absurd to attribute to him, as a scientific achievement, any vast enlargement or further generalization of the modern scientific doctrine of Evolution." To the same effect, Mr. Emerson, when recently called upon by a newspaper interviewer to furnish his opinions of great men, de-

[1] Estimating Spencer, in the *Friend of Progress*, 1864.

clared Mr. Spencer to be nothing better than a "stock-writer, who writes equally well upon all subjects."

These are not the circumspect and instructive utterances which we should look for from men of authority whose opinions are sought and are valued by the public; they are gross and inexcusable misrepresentations, and exemplify a style of criticism that is now so freely indulged in that it requires to be met, in the common interest of justice and truth. By their estimates of Mr. Spencer, the gentlemen quoted have raised the question of his position as a thinker, and the character and claims of his intellectual work. I follow their lead, and propose, on the present occasion, to bring forward some considerations which may help to a more trustworthy judgment upon the subject. Assuming the foregoing statements to be representative, it will be worth while to see what becomes of them under examination. My object will be, less to expound or to defend Mr. Spencer's views, than to trace his mental history, and the quality and extent of his labors, as disclosed by an analysis and review of his published writings.

And, first, let us glance at the general condition of thought in relation to the origination of things when he began its investigation. Character is tested by emergencies, as well in the world of ideas as in the world of action; and it is by his bearing in one of the great crises of our progressive knowledge of Nature that Mr. Spencer is to be measured.

Down to the early part of the present century it had generally been believed that this world, with all that it contains, was suddenly called into existence but a few thousand years ago in much the same condition as we now see it. Throughout Christendom it was held, with the earnestness of religious conviction, that the universe was a Divine manufacture, made out of nothing in a week, and set at once to running in all its present perfection. This doctrine was something more than a mere item of faith; it was a complete theory of the method of origin of natural things, and it gave shape to a whole body of science, philosophy, and common opinion, which was interpreted in accordance with this theory. The problem of *origins* was thus authoritatively solved, and life, mind, man, and all Nature, were studied under the hypothesis of their late and sudden production.

But it was difficult to inquire into the existing order of Nature without tracing it backward. Modern science was long restrained from this procedure by the power of traditional beliefs, but the force of facts and reasoning at length proved too strong for these beliefs, and it was demonstrated that the prevailing notion concerning the recent origin of the world was not true. Overwhelming evidence was found that the universe did not come into existence in the condition in which we now see it, nor in any thing like that condition, but that the present order of things is the outcome of a vast series of changes running back to an indefinite and incalculable antiquity. It was

proved that the present forms and distributions of mountains, valleys, continents, and oceans, are but the final terms of a stupendous course of transformations to which the crust of the earth has been subjected. It was also established that life has stretched back for untold millions of years; that multitudes of its forms arose and perished in a determinate succession, while the last appearing are highest in grade, as if by some principle of order and progression.

It is obvious that one of the great epochs of thought had now been reached; for the point of view from which natural things are to be regarded was fundamentally and forever altered. But, as it is impossible to escape at once and completely from the dominion of old ideas, the full import of the position was far from being recognized, and different classes of the thinking world were naturally very differently affected by the new discoveries. To the mass of people who inherit their opinions and rarely inquire into the grounds upon which they rest, the changed view was of no moment; nor had the geological revelations much interest to the literary classes beyond that of bare curiosity about strange and remote speculations. To the theologians, however, the step that had been taken was of grave concern. They were the proprietors of the old view; they claimed for it supernatural authority, and strenuously maintained that its subversion would be the subversion of religion itself. They maintained, moreover, that the controversy involved the very existence of God. The most familiar conception of the Deity was that of a *Creator*, and *creation* was held to mean the grand six-day drama of calling the universe into existence; while this transcendent display of power had always been devoutly held as alike the exemplification and the proof of the Divine attributes. How deep and tenacious was the old error is shown by the fact that, although it has been completely exploded, although the immeasurable antiquity of the earth and the progressive order of its life have been demonstrated and admitted by all intelligent people, yet the pulpit still clings to the old conceptions, and the traditional view is that which generally prevails among the multitude.

To men of science the new position was, of course, in the highest degree, important. It was stated by Prof. Sedgwick, in an anniversary address to the Geological Society of London, in 1831, as follows: "We have a series of proofs the most emphatic and convincing that the approach to the present system of things has been gradual, and that there has been a progressive development of organic structure subservient to the purposes of life." The traditional explanation of the origin of the world, and all that belongs to it, being thus discredited, it only remained to seek another explanation: if it has not been done one way, how has it been done? was the inevitable question. One might suppose that the effect of the utter break-down of the old hypothesis would have been to relegate the whole question to the sphere of science, but this was far from being done. The preternatu-

ral solution had failed, but its only logical alternative, a natural solution, or the thorough investigation of the subject on principles of causation, was not adopted or urged. The geologists occupied themselves in extending observations and accumulating facts rather than in working out any comprehensive scientific or philosophical principles from the new point of view. The result was a kind of tacit compromise between the contending parties—the theologians conceding the vast antiquity of the earth, and the geologists conceding preternatural intervention in the regular on-working of the scheme; so that, in place of one mighty miracle of creation occurring a few thousand years ago, there was substituted the idea of hundreds of thousands of separate miracles of special creation scattered all along the geological ages, to account for the phenomena of terrestrial life. Two systems of agencies—natural and supernatural—were thus invoked to explain the production of effects. What it now concerns us to note is, that the subject had not yet been brought into the domain of science. One portion of it was still held to be above Nature, and therefore inaccessible to rational inquiry; while that part of the problem which was withheld from science was really the key to the whole situation. Under the new view, the question of the origin of living forms, or of the action of natural agencies in their production, was as completely barred to science as it had formerly been under the literal Mosaic interpretation; and, as questions of origin were thus virtually interdicted, the old traditional opinions regarding the genesis of the present constitution of things remained in full force.

It is in relation to this great crisis in the course of advancing thought that Herbert Spencer is to be regarded. Like many others, he assumed, at the outset, that the study of the whole phenomenal sphere of Nature belongs to science; but he may claim the honor of being the first to discern the full significance of the new intellectual position. It had been proved that a vast course of orderly changes in the past has led up to the present, and is leading on to the future: Mr. Spencer saw that it was of transcendent moment that the laws of these changes be determined. If natural agencies have been at work in vast periods of time to bring about the present condition of things, he perceived that a new set of problems of immense range and importance is open to inquiry, the effect of which must be to work an extensive revolution of ideas. It was apparent to him that the hitherto forbidden question as to how things have originated had at length come to be the supreme question. When the conception that the present order had been called into being at once and in all its completeness was found to be no longer defensible, it was claimed that it makes no difference how it originated—that the existing system is the same whatever may have been its source. Mr. Spencer saw, on the contrary, that the question how things have been caused is fundamental; and that we can have no real understanding of what they are, without first knowing how they

came to be what they are. Starting from the point of view made probable by the astronomers, and demonstrated by the geologists, that, in the mighty past, Nature has conformed to one system of laws; and assuming that the existing order, at any time, is to be regarded as growing out of a preëxisting order, Mr. Spencer saw that nothing remained for science but to consider all the contents of Nature from the same point of view. It was, therefore, apparent that life, mind, man, science, art, language, morality, society, government, and institutions, are things that have undergone a gradual and continuous unfolding, and can be explained in no other way than by a theory of growth and derivation. It is not claimed that Mr. Spencer was the first to adopt this mode of inquiry in relation to special subjects, but that he was the first to grasp it as a general method, the first to see that it must give us a new view of human nature, a new science of mind, a new theory of society—all as parts of one coherent body of thought, and that he was, moreover, the first to work out a comprehensive philosophical system from this point of inquiry, or on the basis of the principle of Evolution. In a word, I maintain Spencer's position as a thinker to be this: taking a view of Nature that was not only generally discredited, but was virtually foreclosed to research, he has done more than any other man to make it the starting-point of a new era of knowledge.

For the proof of this I now appeal to his works. Let us trace the rise and development of the conception of Evolution in his own mind, observe how he was led to it, and how he pursued it, and see how completely it pervades and unifies his entire intellectual career. Various explanatory details that follow, I have obtained from conversations with Mr. Spencer himself; but the essential facts of the statement are derived from his works, and may be easily verified by any who choose to take the trouble of doing so.

Mr. Spencer is not a scholar in the current acceptation of the term; that is, he has not mastered the curriculum of any university. Unbiassed by the traditions of culture, his early studies were in the sciences. Born in a sphere of life which made a vocation necessary, he was educated as a civil-engineer, and up to 1842, when he was twenty-two years of age, he had written nothing but professional papers published in the *Civil Engineer and Architects' Journal*. But he had always been keenly interested in political and social questions, which he had almost daily heard discussed by his father and uncles. In the summer of 1842 he began to contribute a series of letters to a weekly newspaper, the *Nonconformist*, under the title of "The Proper Sphere of Government." It was the main object of these letters to show that the functions of government should be limited to the protection of life, property, and social order, leaving all other social ends to be achieved by individual activities. But, beyond this main conception, it was implied throughout that there are such things

as laws of social development, natural processes of rectification in society, and an adaptation of man to the conditions of social life. The scientific point of view was thus early assumed, and society was regarded not as a manufacture but as a growth. These letters were revised and published in a pamphlet in 1843.

The argument, however, was unsatisfactory from its want of depth and scientific precision, and Mr. Spencer decided in 1846 to write a work in which the leading doctrine of his pamphlet should be affiliated upon general moral principles. By reading various books upon moral philosophy he had become dissatisfied with the basis of morality which they adopt; and it became clear to him that the question of the proper sphere of government could be dealt with only by tracing ethical principles to their roots. The plan of this work was formed while Mr. Spencer was still a civil-engineer; and it was commenced in 1848, before he abandoned engineering and accepted the position of sub-editor of the *Economist*. It was issued, under the title of "Social Statics," at the close of 1850. In this work various developments of the ideas contained in the pamphlet above named are noticeable. It will be seen that the conception that there is an adaptation going on between human nature and the social state has become dominant. There is the idea that all social evils result from the want of this adaptation, and are in process of disappearance as the adaptation progresses. There is the notion that all morality consists in conformity to such principles of conduct as allow of the life of each individual being fulfilled, to the uttermost, consistently with the fulfillment of the lives of other individuals; and that the vital activities of the social human being are gradually being moulded into such form that they may be realized to the uttermost without mutual hindrance. Social progress is in fact viewed as a natural evolution, in which human beings are moulded into fitness for the social state, and society adjusted into fitness for the natures of men—the units and the aggregate perpetually acting and reacting, until equilibrium is reached. There is recognized not only the process of continual direct adaptation of men to their circumstances by the inherited modifications of habit, but there is also recognized the process of the dying out of the unfit and the survival of the fit. And these changes are regarded as parts of a process of general evolution, tacitly affirmed as running through all animate Nature, tending ever to produce a more complete and self-sufficing individuality, and ending in the highest type of man as the most complete individual.

After finishing "Social Statics" Mr. Spencer's thoughts were more strongly attracted in the directions of biology and psychology—sciences which he saw were most intimately related with the progress of social questions; and one result reached at this time was significant. As he states in the essay on the "Laws of Organic Form," published in 1859 in the *Medico-Chirurgical Review*, it was in the autumn of 1851, during a country ramble with Mr. George Henry Lewes, that the germinal

idea of that essay was reached. This idea, that the forms of organisms, in respect of the different kinds of their symmetry and asymmetry, are caused by their different relations to surrounding incident forces, implies a general recognition of the doctrine of Evolution, a further extension of the doctrine of adaptation, and a foreshadowing of the theory of life as a correspondence between inner and outer actions.

In 1852 Mr. Spencer published in the *Westminster Review* the "Theory of Population deduced from the General Law of Animal Fertility," setting forth an important principle which he says that he had entertained as far back as 1847. Here also the general belief in Evolution was tacitly expressed; the theory being that, in proportion as the power of maintaining individual life is small, the power of multiplication is great; that along with increased evolution of the individual there goes decreased power of reproduction; that the one change is the cause of the other; that in man as in all other creatures the advance toward a higher type will be accompanied by a decrease of fertility; and that there will be eventually reached an approximate equilibrium between the rate of mortality and the rate of multiplication. Toward the close of this argument there is a clear recognition of the important fact that excessive multiplication and the consequent struggle for existence cause this advance to a higher type. It is there argued that "only those who do advance under it eventually *survive*," and that these "must be the *select* of their generation." That which, as he subsequently stated in the "Principles of Biology," Mr. Spencer failed to recognize at this time (1852) was the effect of these influences in producing the *diversities* of living forms; that is, he did not then perceive the coöperation of these actions of the struggle for existence and the survival of the fittest with the tendency to variation which organisms exhibit. He saw only the power of these processes to produce a higher form of the same type, and did not recognize how they may give rise to divergencies and consequent differentiations of species, and eventually of genera, orders, and classes.

Early in 1852, Mr. Spencer also printed a brief essay in the *Leader*, on "The Development Hypothesis," in which some of the now current reasons for believing in the gradual evolution of all organisms, including man, are indicated. To this paper Mr. Darwin refers in the introductory sketch of the previous course of research on the subject of development, which he prefixed to the "Origin of Species." In this essay, however, *direct* adaptation to the conditions of existence is the only process recognized.

In October of the same year (1852), Mr. Spencer published an essay in the *Westminster Review*, on the "Philosophy of Style," in which, though the subject appears so remote, there are traceable some of the cardinal ideas now indicated, and others that were afterward developed. The subject was treated from a dynamical point of view, and, as Mr. Lewes remarks in his essays on the "Principles of Success

in Literature," it offers the only scientific exposition of the problem of style that we have. The general theory set forth is, that effectiveness of style depends on a choice of words and forms of sentence offering the *least resistance* to thought in the mind of the reader or hearer —a foreshadowing of the general law of the "line of least resistance" as applied to the interpretation of psychological phenomena, as well as phenomena in general. Moreover, at the close of the essay, there is a reference to the law of Evolution in its application to speech—there is a recognition of the fact that "increasing heterogeneity" has been the characteristic of advance in this as in other things, and that a highly-evolved style will "answer to the description of all highly-organized products, both of man and of Nature; it will be, not a series of like parts simply placed in juxtaposition, but one whole made up of unlike parts that are mutually dependent." Here, as early as 1852, there are recognized in one of the highest spheres both the process of differentiation and the process of integration—the two radical conceptions of Evolution.

In July of the next year (1853), Mr. Spencer's continued interest in the question of the functions of the state led him to write the essay on "Over-Legislation" in the *Westminster Review;* and here, as in "Social Statics," the conception of society as a growth, under the operation of natural laws, is predominant.

The critical perusal of Mr. Spencer's works shows that this was a very important period in the development of his views. The reading of Mr. Mill's "Logic," along with some other philosophical works, had led him to the elaboration of certain opinions at variance with those of Mr. Mill on the question of our ultimate beliefs, and those he published in the *Westminster Review*, under the title of "The Universal Postulate" (1853). The inquiries thus commenced, together with those respecting the nature of the moral feelings, and those concerning life and development, bodily and mental, into which he had been led, both by "Social Statics" and the "Theory of Population," prepared the way for the "Principles of Psychology." Some of the fundamental conceptions contained in this remarkable work now began to take shape in his mind. Other ideas connected with the subject began also to form in his mind, an example of which is furnished by the essay on "Manners and Fashion," published in the *Westminster Review* (April, 1854). Various traits of the general doctrine of Evolution are here clearly marked out in their relations to social progress. It is shown that the various forms of restraint exercised over men in society—political, ecclesiastical, and ceremonial—are all divergent unfoldings of one original form, and that the development of social structure, in these as in other directions, takes place by gradual and continuous differentiations, "in conformity with the laws of Evolution of all organized bodies."

Mr. Spencer was at the same time engaged in working out his

view in a different sphere, the essay on the "Genesis of Science" being contributed to the *British Quarterly Review* in July, 1854. This was primarily called forth by Miss Martineau's "Abridgment of Comte," then just issued, and was in part devoted to the refutation of the French philosopher's views respecting the classification of the sciences. But it became the occasion for a further development of the doctrine of Evolution in its relation to intellectual progress. The whole genesis of science is there traced out historically under the aspect of a body of truths, which, while they became differentiated into different sciences, became at the same time more and more integrated, or mutually dependent, so as eventually to form "an organism of the sciences." There is, besides, a recognition of the gradual increase in definiteness that accompanies this increase in heterogeneity and in coherence.

It was at this time that Mr. Spencer's views on psychology began to assume the character of a system—the conception of intellectual progress now reached being combined with the ideas of life previously arrived at, in the development of a psychological theory. The essay on the "Art of Education,"[1] published in the *North British Review* (May, 1854), assisted in the further development of these ideas. In that essay the conception of the progress of the mind during education is treated in harmony with the conception of mental Evolution at large. Methods are considered in relation to the law of development of the faculties, as it takes place naturally. Education is regarded as rightly carried on only when it aids the process of self-development; and it is urged that the course in all cases followed should be from the simple to the complex, from the indefinite to the definite, from the concrete to the abstract, and from the empirical to the rational.

Having reached this stage in the unfolding of his ideas, Mr. Spencer began the writing of the "Principles of Psychology" in August, 1854. This is a work of great originality, and is important as marking the advance of Mr. Spencer's philosophical views at the time of its preparation. The whole subject of mind is dealt with from the Evolution point of view. The idea which runs through "Social Statics," that there is ever going on an adaptation between living beings and their circumstances, now took on a profounder significance. The *relation* between the organism and its environing conditions was found to be involved in the very nature of life; and the idea of adaptation was developed into the conception that life itself "is the definite combination of heterogeneous changes, both simultaneous and successive in correspondence with external coexistences and sequences." It is argued that the degree of life varies with the degree of correspondence, and that all mental phenomena ought to be interpreted in terms

[1] Republished in his little work on "Education," under the title of "Intellectual Education."

of this correspondence. Commencing with the lowest types of life, Mr. Spencer, in successive chapters, traces up this relation of correspondence as extending in space and time, as increasing in specialty, in generality, and in complexity. It is also shown that the correspondence progresses from a more homogeneous to a more heterogeneous form, and that it becomes gradually more integrated—the terms here employed, in respect to the Evolution of mind, being the terms subsequently used in treating of Evolution in general. In the fourth part of the work, under the title of "Special Synthesis," the Evolution is traced out under its concrete form from reflex action up through instinct, memory, reason, feelings, and the will. Mr. Spencer here distinctly avowed his belief that "Life, in its multitudinous and infinitely varied embodiments, has arisen out of the lowest and simplest beginnings, by steps as gradual as those which evolve a homogeneous microscopic germ into a complex organism"—dissent being, at the same time, expressed from that version of the doctrine put forth by the author of the "Vestiges of the Natural History of Creation." It was, moreover, shown by subjective analysis how intelligence may be resolved, step by step, from its most complex into its simplest elements; and it was also proved that there is "unity of composition" throughout, and that thus mental structure, contemplated internally, harmonizes with the doctrine of Evolution.

It was at this time (1854), as I have been informed by Mr. Spencer, when he had been at work upon the "Principles of Psychology" not more than two months, that the general conception of Evolution in its causes and extent, as well as its processes, was arrived at. He had somewhat earlier conceived of it as universally a transformation from the homogeneous into the heterogeneous. This kind of change which Von Baer had shown to take place in every individual organism, as it develops, Mr. Spencer had already traced out as taking place in the progress of social arrangements, in the development of the sciences, and now in the Evolution of mind in general from the lower forms to the higher. And the generalization soon extended itself so as to embrace the transformations undergone by all things inanimate as well as animate. This universal extension of the idea led rapidly to the conception of a universal cause necessitating it. In the autumn of 1854, Mr. Spencer proposed to the editor of the *Westminster Review* to write an article upon the subject under the title of "The Cause of all Progress," which was objected to as being too assuming. The article was, however, at that time agreed upon, with the understanding that it should be written as soon as the "Principles of Psychology" was finished. The agreement was doomed to be defeated, however, so far as the date was concerned, for, along with the completion of the "Psychology," in July, 1855, there came a nervous break-down, which incapacitated Mr. Spencer for labor during a period of eighteen months —the whole work having been written in less than a year.

We may here note Mr. Spencer's advanced position in dealing with this subject. While yet the notion of Evolution as a process of Nature was as vague and speculative as it had been in the time of Anaximander and Democritus, he had grasped the problem in its universality and its causes, and had successfully applied it to one of the most difficult and important of the sciences. He had traced the operation of the law in the sphere of mind, and placed that study upon a new basis. The conviction is now entertained by many that the "Principles of Psychology," by Spencer, in 1855, is one of the most original and masterly scientific treatises of the present century, if, indeed, it be not the most fruitful contribution to scientific thought that has appeared since the "Principia" of Newton.[1] For thousands of years, from Plato to Hamilton, the world's ablest thinkers had been engaged in the effort to elucidate the phenomena of mind; Herbert Spencer took up the question by a method first rendered possible by modern science, and made a new epoch in its progress. From this time forward, mental philosophy, so called, could not confine itself to introspection of the adult human consciousness. The philosophy of mind must deal with the whole range of psychical phenomena, must deal with them as manifestations of organic life, must deal with them genetically, and show how mind is constituted in connection with the experience of the past. In short, as it now begins to be widely recognized, Mr. Spencer has placed the science of mind firmly upon the ground of Evolution. Like all productions that are at the same time new and profound, and go athwart the course of long tradition, there were but few that appreciated his book, a single small edition more than sufficing to meet the wants of the public for a dozen years. But it began at once to tell upon advanced thinkers, and its influence was soon widely discerned in the best literature of the subject. The man who stood, perhaps, highest in England as a psychologist, Mr. John Stuart Mill, remarked in one of his books, that "it is one of the finest examples we possess of the psychological method in its full power;" and, as I am aware, after carefully rereading it some years later, he declared that his already high opinion of the work had been raised

[1] This association of the name of Spencer with Newton, let it be remembered, does not rest upon the authority of the present writer; recent discussions of the subject in the highest quarters are full of it. The *Saturday Review* says, "Since Newton there has not in England been a philosopher of more remarkable speculative and systematizing talent than (spite of some errors and some narrowness) Mr. Herbert Spencer." An able writer in the *Quarterly Review*, in treating of Mr. Spencer's remarkable power of binding together different and distant subjects of thought by the principle of Evolution, remarks: "The two deepest scientific principles now known of all those relating to material things are the Law of Gravitation and the Law of Evolution." The eminent Professor of Logic in Owens College, Manchester, Mr. W. Stanley Jevons, in his recent treatise entitled "The Principles of Science, a Treatise on Logic and Scientific Method," says, "I question whether any scientific works which have appeared, since the 'Principia' of Newton, are comparable in importance with those of Darwin and Spencer, revolutionizing as they do all our views of the origin of bodily, mental, moral, and social phenomena."

still more—which he recognized as due to the progress of his own mind.

The article "Progress, its Law and Cause," projected, as we have seen, in 1854, was written early in 1857. In the first half of it the transformation of the homogeneous into the heterogeneous is traced throughout all orders of phenomena; in the second half the principle of transformation is deduced from the law of the multiplication of effects. In this essay, moreover, there is indicated the application of the general law of Evolution to the production of species. It is shown that there "would not be a substitution of a thousand more or less modified species for the thousand original species; but, in place of the thousand modified species, there would arise several thousand species, or varieties, or changed forms;" and that "each original race of organisms would become the root from which diverged several races differing more or less from it and from each other." It is further argued that the new relations in which animals would be placed toward one another would initiate further differences of habit and consequent modifications, and that "there must arise, not simply a tendency toward the differentiations of each race of organisms into several races, but also a tendency to the occasional production of a somewhat higher organism." The case of the divergent varieties of man, some of them higher than others, caused in this same manner, is given in illustration. Throughout the argument there is a tacit implication that, as a consequence of the cause of Evolution, the production of species will go on, not in ascending linear series, but by perpetual divergence and redivergence—branching and again branching. The general conception, however, differs from that of Mr. Darwin in this—that adaptation and readaptation to continually-changing conditions is the only process recognized—there is no recognition of "spontaneous variations," and the natural selection of those that are favorable.

During the summer of 1857 Mr. Spencer wrote the "Origin and Function of Music," published in *Fraser's Magazine* for October. Like nearly all of his other writings, this interesting article is dominated by the idea of Evolution. The general law of nervo-motor action in all animals is shown to furnish an explanation of the tones and cadences of emotional speech; and it is pointed out that from these music is evolved by simple exaltation of all the distinctive traits, and carrying them out into ideal combination. A further step was taken, the same year, in the development of the doctrine of Evolution, which is indicated in the article entitled "Transcendental Physiology." It was there explained that the multiplication of effects was not the only cause of the universal change from homogeneity to heterogeneity, but that there was an antecedent principle to be recognized, viz., the *Instability of the Homogeneous*. The physiological illustrations of the law are mainly dwelt upon, though its other applications are indicated.

In October of the same year, the essay on "Representative Government—what is it good for?" appeared in the *Westminster Review*. The law of progress is here applied to the interpretation of state functions, and it is stated that the specialization of offices, "as exhibited in the Evolution of living creatures, and as exhibited in the Evolution of societies," holds throughout; that "the governmental part of the body politic exemplifies this truth equally with its other parts." In January, 1858, the essay on "State Tamperings with Money and Banks" appeared in the same periodical. The general doctrine of the limitations of state functions is there reaffirmed, with further illustration of the mischiefs that arise from traversing the normal laws of life; and it is contended that "the ultimate result of shielding men from the effects of folly is to fill the world with fools"—an indirect way of asserting the beneficial effects of the survival of the fittest.

In April, 1858, Mr. Spencer published an essay on "Moral Education," in the *British Quarterly Review*, and throughout the argument every thing is again regarded from the Evolution point of view. The general truth insisted upon is, that the natural rewards and restraints of conduct are those which are most appropriate and effectual in modifying character. The principle contended for is, that the moral education of every child should be regarded as an adaptation of its nature to the circumstances of life; and that to become adapted to these circumstances it must be allowed to come in contact with them; must be allowed to suffer the pains and obtain the pleasures which do in the order of Nature follow certain kinds of action. There is here, in fact, applied to actual life, the general conception of the nature of life, previously inculcated in the "Principles of Psychology"—a correspondence between the inner and the outer actions that becomes great in proportion as the converse with outer actions through experience becomes extended.

The essay on the "Nebular Hypothesis" was published in the *Westminster Review* for July, 1858. The opinion was then almost universally held that the nebular hypothesis had been exploded, and the obvious bearing of the question upon the theory of Evolution induced Mr. Spencer to take it up. The conclusions that had been drawn from observations with Lord Rosse's telescope, that the nebular hypothesis had been invalidated, were shown to be erroneous; and the position taken, that the nebulæ could not be (as they were then supposed to be) remote sidereal systems, has been since verified. Spectrum analysis has, in fact, proved what Mr. Spencer then maintained, that there are many nebulæ composed of gaseous matter. To the various indications of the nebular origin of our own solar system commonly given, others were added which had not been previously recognized, while the view that Mr. Spencer took of the constitution of the solar atmosphere has since been also verified by spectrum analysis.

In October, 1858, he published in the *Medico-Chirurgical Review* a criticism on Prof. Owen's "Archetype and Homologies of the Vertebrate Skeleton," which was written in furtherance of the doctrine of Evolution, and to show that the structural peculiarities which are not accounted for on the theory of an archetypal vertebra, are accounted for on the hypothesis of development. In January of the next year, there appeared in the same review a paper on "The Laws of Organic Form," already referred to, the germ of which dated back to 1851, and which was a further elucidation of the doctrine of Evolution, by showing the direct action of incident forces in modifying the forms of organisms and their parts. In April, 1859, appeared in the *British Quarterly Review* an article on "Physical Education," in which the bearing of biological principles upon the management of children in respect to their bodily development is considered. It insists upon the normal course of unfolding, *versus* those hindrances to it which ordinary school regulations impose; it asserts the worth of the bodily appetites and impulses in children, which are commonly so much thwarted; and contends that during this earlier portion of life, in which the main thing to be done is to grow and develop, our educational system is too exacting—"it makes the juvenile life far more like the adult life than it should be." The essay "What Knowledge is of most Worth" was printed in the *Westminster Review* for July, 1859. This argument is familiar to the public, as it has been many times republished, but what is here most worthy of note is that, in criticising the current study of history, it defines with great distinctness the plan of the "Descriptive Sociology," the first divisions of which are now just published, and form the comprehensive and systematic data upon which the Principles of Sociology are to be based.

An argument on "Illogical Geology" was contributed in July, 1859, to the *Universal Review*, which, although nominally a criticism of Hugh Miller, was really an attack upon the prevalent geological doctrine which asserted simultaneity in the systems of strata in different parts of the earth. His view, which was at that time heresy, is now coming into general recognition. In the *Medico-Chirurgical Review* for January, 1860, Mr. Spencer published a criticism on Prof. Bain's work, "The Emotions and the Will," designed to show that the emotions cannot be properly understood and classified without studying them from the point of view of Evolution, and tracing them up through their increasing complications from lower types of animals to higher. The essay on the "Social Organism" appeared at the same time in the *Westminster Review*, in which it was maintained that society, consisting of an organized aggregate, follows the same course of Evolution with all other organized aggregates—increasing in mass and showing a higher integration not only in this respect but also in its growing solidarity; becoming more and more heterogeneous in all its structures and more and more definite in all its differentiations. The

"Physiology of Laughter," which appeared the same year in *Macmillan's Magazine*, was a contribution to nervous dynamics from the point of view that had been taken in the "Principles of Psychology." Even in Mr. Spencer's discussion of "Parliamentary Reforms, their Dangers and Safeguards" (*Westminster Review*, 1860), the question is dealt with on scientific grounds ultimately referring to the doctrine of Evolution. It was its general purpose to show that the basis of political power can be safely extended only in proportion as political function is more and more restricted. It was maintained in an earlier essay that representative government is the best possible for that which is the essential office of a government—the maintenance of those social conditions under which every citizen can carry on securely and without hindrance the pursuits of life—and that it is the worst possible for other purposes. And in continuation of this argument it was here contended that further extension of popular power should be accompanied by a further restriction of state duty—a further specialization of state function. In the essay on "Prison Ethics," contributed to the *British Quarterly Review* in July, 1860, a special question is very ably dealt with in the light of those biological, psychological, and sociological principles which belong to the Evolution philosophy. The principle of moral Evolution is asserted and the concomitant unfolding of higher and better modes of dealing with criminals.

We have now passed in rapid review the intellectual work of Mr. Spencer for nearly twenty years, and have shown that, though apparently miscellaneous, it was, in reality, of a highly methodical character. Though treating of many subjects, he was steadily engaged with an extensive problem which was resolved, step by step, through the successive discovery of those processes and principles of Nature which constitute the general law of Evolution. Beginning in 1842 with the vague conception of a social progress, he subjected this idea to systematic scientific analysis, gave it gradually a more definite and comprehensive form, propounded the principles of heredity and adaptation in their social applications, recognized the working of the principle of selection in the case of human beings, and affiliated the conception of social progress upon the more general principle of Evolution governing all animate Nature. Seizing the idea of increasing heterogeneity in organic growth, he gradually extended it in various directions. When the great conception, thus pursued, had grown into a clear, coherent, and well-defined doctrine, he took up the subject of psychology, and, combining the principle of differentiation with that of integration, he placed the interpretation of mental phenomena upon the basis of Evolution. We have seen that two years after the publication of the "Psychology," or in 1857, Mr. Spencer had arrived at the law of Evolution as a universal principle of Nature, and worked it out both inductively as a process of increasing heterogeneity and

deductively from the principles of the instability of the homogeneous and the multiplication of effects. How far Mr. Spencer was here in advance of all other workers in this field will appear, when we consider that the doctrine of Evolution, as it now stands, was thus, in its universality, and in its chief outlines, announced by him two years before the appearance of Mr. Darwin's "Origin of Species."

A principle of natural changes more universal than any other known, applicable to all orders of phenomena, and so deep as to involve the very origin of things, having thus been established, the final step remained to be taken, which was, to give it the same ruling place in the world of thought and of knowledge that it has in the world of fact and of Nature. A principle running through all spheres of phenomena must have the highest value for determining scientific relations; and a genetic law of natural things must necessarily form the deepest root of the philosophy of natural things. It was in 1858, as Mr. Spencer informs me, while writing the article on the "Nebular Hypothesis," that the doctrine of Evolution presented itself as the basis of a general system under which all orders of concrete phenomena should be generalized. Already the conception had been traced out in its applications to astronomy, geology, biology, psychology, as well as all the various super-organic products of social activity; and it began to appear both possible and necessary that all these various concrete sciences should be dealt with in detail from the Evolution point of view. By such treatment, and by that only, did it appear practicable to bring them into relation so as to form a coherent body of scientific truth—a System of Philosophy.

It is proper in this place to state that, in contemplating the execution of so comprehensive a work, the first difficulty that arose was a pecuniary one. Mr. Spencer had frittered away the greater part of what little he possessed in writing and publishing books that did not pay their expenses, and a period of eighteen months of ill-health and enforced idleness consequent on the writing of one of them had further diminished his resources. His state of health was still such that he could work, at the outside, but three hours a day, and very frequently not even that, so that what little he could do in the shape of writing for periodicals, even though tolerably paid for it, did not suffice to meet the expenses of a very economical bachelor-life. How, then, could he reasonably hope to prosecute a scheme elaborating the doctrine of Evolution throughout all its departments in the way contemplated—a scheme that would involve an enormous amount of thought, labor, and inquiry, and which seemed very unlikely to bring any pecuniary return, even if it paid its expenses? Unable to see any solution of the difficulty, Mr. Spencer wrote, in July, 1858, to Mr. John Stuart Mill, explaining his project, and asking whether he thought that in the administration for India, in which Mr. Mill held office, there was likely to be any post, rather of trust than of much

work, which would leave him leisure enough for the execution of his scheme. Mr. Mill replied sympathetically, but nothing turned out to be available. In despair of any other possibility, Mr. Spencer afterward extended his application to the Government; being reënforced by the influence of various leading scientific men, who expressed themselves strongly respecting the importance of giving him the opportunity he wished. A peculiar difficulty, however, here arose. Mr. Spencer is a very impracticable man—that is, he undertakes to conform his conduct to right principles, and his decided views as to the proper functions of government put an interdict upon the far greater number of posts that might otherwise be fit. Among the few that he could accept, the greater part were not available because they did not offer the requisite leisure. One position became vacant which he might have accepted, that of Inspector of Prisons, I think; but, though effort in his behalf was made by Lord Stanley (now Lord Derby, who was familiar with Mr. Spencer's works and entertained the matter with interest), the claims of party were too strong, and no arrangement was made.

Other plans failing, Mr. Spencer decided to adopt the plan of subscription, and issue his "System of Philosophy" in a serial form. A prospectus of that system was issued in March, 1860, which outlined the contents of the successive parts. The first installment of the work was issued in October, 1860, and the commencing volume, "First Principles," was published in June, 1862.

In this work the general doctrine of Evolution is presented in a greatly developed form; and the author's former views are not only combined but extended. The law of Von Baer, which formulates organic development as a transformation of the homogeneous into the heterogeneous, Mr. Spencer had previously shown to hold of all aggregates whatever—of the universe as a whole and of all its component parts. But, in "First Principles," it was shown that this universal transformation is a change from *indefinite* homogeneity to *definite* heterogeneity; and it is pointed out that only when the increasing multiformity is joined with increasing definiteness, does it constitute Evolution as distinguished from other changes that are like it in respect of increasing heterogeneity. This is, however, a much more important development of the principle. This change from the indefinite to the definite is shown to be the accompaniment of a more essential change from the incoherent to the coherent. Throughout all aggregates of all orders it is proved that there goes on a process of *integration*. This process is shown to hold alike in the growth and consolidation of each aggregate as well as in the growth and consolidation of its differentiated parts. The law of the instability of the homogeneous is also more elaborately traced out. Under the head of the *principle of segregation* it is, moreover, shown that the universal process by which, in aggregates of mixed units, the

units of like kinds tend to gather together, and the units of unlike kinds to separate, everywhere coöperates in aiding Evolution. Yet a further universal law is recognized and developed—the law of equilibration. The question is asked, "Can these changes which constitute Evolution continue without limit?" and the answer given is that they cannot; but that they universally tend in each aggregate toward a final state of quiescence, in which all the forces at work have reached a state of balance. Like the other universal processes, that of equilibration is traced out in all divisions of phenomena. But the most important development given to the doctrine of Evolution in this volume was its affiliation upon the ultimate principle underlying all science—the persistence of force. It was shown that from this ultimate law there result certain universal derivative laws, which are dealt with in chapters on "The Correlation and Equivalence of Forces," "The Direction of Motion," and "The Rhythm of Motion," and it was demonstrated that these derivative laws hold throughout all changes from the astronomical to the psychical and social. It is then shown that "the Instability of the Homogeneous," "The Multiplication of Effects," "Segregation" and "Equilibration," are also deducible from this ultimate principle of the persistence of force. So that Evolution, having been first established inductively as universal, is further shown to be universal by establishing it deductively as a result of the deepest of all knowable truths.

The first edition of "First Principles" was published, but another important step in elucidating the philosophy of Evolution required to be taken. In dealing with the classification of the sciences, from the point of view to which his philosophy has brought him, Mr. Spencer had occasion to seek for that aspect of all physical phenomena which forms the most general division of physical science. He found that what he sought must be some general fact respecting the redistribution of matter and motion. The law was soon arrived at that integration of matter results from decrease of the contained motion, while disintegration of matter results from increase of the contained motion. It is at once manifest that the law thus reached was deeper than the principle of Evolution, for it is conformed to by mineral bodies which do not exhibit the phenomena of Evolution as Mr. Spencer had interpreted them. In short, it became clear that a law had been reached holding of all material things whatever, whether they are those which do, or those which do not, increase in heterogeneity. It was now first possible to judge of the relative value and importance of the several factors of the evolutionary process. In Von Baer's conception of organic development, it is made to consist essentially and solely in the change of increasing heterogeneity in the evolving body. But Mr. Spencer had shown that Evolution is a double process—a tendency to unity as well as to diversity, an integration as well as a differentiation. It was now found that the process of *integration*, as it applies

to all things, whether evolving or not, is a deeper principle, and is, in fact, the *primary process* in Evolution, while the increase of heterogeneity is the *secondary process*. At the same time, this new view of the matter made it obvious that Dissolution is everywhere the correlative of Evolution, and that, before the generalization is complete, Dissolution must be recognized as universally tending to undo what Evolution does.

In a new edition of "First Principles," this idea was embodied, and the work recast in conformity with it. The doctrine of Evolution thus attained a higher development. The fundamental antagonism between Evolution and Dissolution comes into the foreground as the cardinal conception. It is shown that every aggregate, simple or compound, is, from the beginning to the end of its existence, subject to these opposing processes of change; that, according as its quantity of contained motion is becoming greater or less, it is tending to integrate or disintegrate—evolve or dissolve; that from moment to moment throughout its whole existence it is simultaneously exposed to both these processes, and that the average transformation it is undergoing expresses the predominance of the one process over the other. This being the universal law to which all material things at all times are subject, there come to be recognized certain derivative laws that are not universal, although highly general. Evolution is distinguished into simple and compound: simple Evolution being that in which the character of the matter and the rate of its integration are such that this primary process of change from a diffused state to a concentrated state is uncomplicated by secondary changes—compound Evolution being that in which, along with the general integrations, there go on more or less marked differentiations and local integrations. Thus the changes which were originally conceived to constitute Evolution itself came to be recognized as in order of time and importance subordinate; integration may go on without differentiation, as in crystals; but differentiation is made possible only by antecedent integration.

The doctrine of Evolution as a theory of the genesis and dissolution of things in the onward course of Nature was elaborately presented in "First Principles," and might have been there left to take its place and its chance among philosophical theories. But it had not been exploited by Mr. Spencer in the way of mental gymnastics, as a piece of novel and ingenious speculation. He believed it to embody a living and applicable principle of the greatest moment. If the law of Evolution be true, it is a truth of transcendent import, no less in the sphere of practical life than in the world of thought, and it was important that it should be carried out in the various fields of its application. Moreover, Mr. Spencer had been drawn to the investigation by his interest in the study of human affairs, and his task was but fairly begun with the establishment of the principle by which they are to be interpreted. In the strict logical order the next step would have been

to trace the operation of the law in the inorganic or preorganic world, but the vastness of the subject forbade this, and Mr. Spencer found it necessary to enter at once upon the organic division of his scheme. In the "Principles of Biology" the subject of life was accordingly comprehensively dealt with from the Evolution point of view. He then passed to the phenomena of mind, and recast and amplified the "Principles of Psychology" in accordance with his more matured opinions, placing it upon the ampler basis afforded by "First Principles" and the "Principles of Biology." These three works, forming five volumes of the System of Philosophy, are now published, and they carry him half through the undertaking—the "Principles of Sociology," in three volumes, and the "Principles of Morality," in two volumes, remaining yet to be written. Mr. Spencer allowed twenty years for the whole enterprise; ill health and unforeseen interruptions have occasioned considerable delay, and it was half accomplished in twelve years.

A further illustration of the comprehensive and thoroughly systematic character of Mr. Spencer's work is afforded by his preparation for the treatment of the subject of Sociology. In dealing with Biology and Psychology, the data for reasoning were readily accessible, but in entering upon the scientific study of so vast and varied a subject as human society a most formidable difficulty appeared at the threshold of the inquiry, in the absence of facts to form the basis of sociological reasoning. So deficient and scattered and contradictory were such data that the possibility of any valid social science has been generally regarded with distrust, or unhesitatingly denied. But the phenomena of society are not chaotic; they coexist and succeed each other in an orderly way. The natural laws of the social state are undoubtedly determinable, but such determination is primarily a question of the collection of materials suitable for broad and safe inductions. Mr. Spencer foresaw this several years ago, and began the collection and methodical arrangement of all those numerous classes of facts pertaining to the various forms and states of society which are needed to work out the "Principles of Sociology." This alone was an immense undertaking. The races of mankind were divided into three groups, illustrating existing civilizations, extinct or decayed civilizations, and the savage state. Three corresponding series of works were projected, a tabular method for the classification and arrangement of facts was devised, and three gentlemen were employed to carry out the work of collection and digestion of materials under Mr. Spencer's supervision. The first installments of each of these divisions are now completed, and published. This important work, which is subsidiary to his main enterprise, is the first of the kind ever attempted, and when finished and issued will form a complete Cyclopædia of the multifarious data necessary for the scientific investigation of social questions. Its continued publication will depend upon public support; but the collection has been made by Mr. Spencer for his own use, and it will form the ground-

work of the "Principles of Sociology" upon which he has now entered, and the first part of which is issued.

Let us now recapitulate his labors in the order of their accomplishment, so as to bring them into one view:

Letters on the Proper Sphere of Government,	1842
(Occupied several years as a Railroad Engineer.)	
Planned Social Statics,	1846
Social Statics published,	1850
Theory of Population, The Development Hypothesis, Philosophy of Style,	1852
Over-Legislation, The Universal Postulate,	1853
Manners and Fashion, The Genesis of Science, The Art of Education, *Evolution first conceived as Universal,*	1854
Principles of Psychology,	1855
(Breakdown of eighteen months.)	
Progress, its Law and Cause, Origin and Function of Music, Transcendental Physiology, Representative Government,	1857
State Tamperings with Money and Banks, Moral Education, The Nebular Hypothesis, Archetype and Homologies of the Vertebrate Skeleton, *Evolution first conceived as the Basis of a System of Philosophy,*	1858
The Laws of Organic Form, Physical Education, What Knowledge is of most Worth, Illogical Geology, *Prospectus of the System of Philosophy drawn up,*	1859
The Emotions and the Will, The Social Organism, The Physiology of Laughter, Parliamentary Reforms, Prison Ethics, *Prospectus of the Philosophical System published,*	1860
First Principles,	1862
Classification of the Sciences,	1864
Principles of Biology,	1867
Principles of Psychology,	1872
The Study of Sociology, Descriptive Sociology,	1873
Principles of Sociology, Part I.,	1874

The facts now presented, I submit, entirely sustain the view with which we set out, in regard to the character of Mr. Spencer's work, and his position in the world of thought. It has been shown that he took up the idea of Progress while it was only a vague speculation, and had not yet become a subject of serious scientific study. We have seen that he verified its reality by gradually tracing its operation

step by step, in widely different fields of phenomena; that he analyzed its conditions and causes, and at length formulated it as a universal principle, to which the course of all things conforms. That view of the universe which the science of the world now accepts, it has been shown that Mr. Spencer adopted a generation ago, and entered upon its elucidation as a systematic life-work. We have traced the course of its unfolding, and I appeal to the record of labors here delineated as furnishing an example of original, continuous, and concentrated thinking, which it will be difficult to parallel in the history of intellectual achievement. In newness of conception, unity of purpose, subtlety of analyses, comprehensive grasp, thoroughness of method, and sustained force of execution, this series of labors, I believe, may challenge comparison with the highest mental work of any age.

As to the character of the system of thought which Mr. Spencer has elaborated, we have shown that it is such as to form an important epoch in the advance of knowledge. He took up an idea not yet investigated nor entertained by his predecessors or contemporaries, and has made it the corner-stone of a philosophy. If, by philosophy, we understand the deepest explanation of things that is possible to the human mind, the principle of genesis or Evolution certainly answers preëminently to this character; for what explanation can go deeper than that which accounts for the origin, continuance, and disappearance of the changing objects around us? It is the newest solution of the oldest problem; a solution based alike upon the most extended knowledge, and upon a reverent recognition that all human investigation, however extensive, must have its inexorable bounds. The philosophy of Evolution is truly a philosophy of creation, carried as far as the human mind can penetrate. If man is finite, the infinite is beyond him; if finite, he is limited, and his knowledge, and all the philosophy that rests upon knowledge, must be also limited. Philosophy is a system of truth pertaining to the order of Nature, and coextensive with it; and, as the various sciences are but the knowledge of the different parts of Nature, Mr. Spencer bases philosophy upon science, and makes it what may be called a science of the sciences. Resting, moreover, upon a universal law, which governs the course and changes of all phenomena, this philosophy becomes powerful to unify and harmonize the hitherto separate and fragmentary systems of truth; and, as this is the predominant trait of Mr. Spencer's system of thought, he very properly denominates it the *Synthetic Philosophy*.

In estimating the character of Mr. Spencer's Philosophical System, it is needful to remember that it differs in various fundamental respects from any that has before been offered to the world. It is more logically complete than any other system, because its truths are first derived from facts and phenomena by the method of induction, and then systematically verified by deduction from principles

already established. It is more practical than any other, because it bears immediately upon common experience, takes hold of the living questions of the time, throws light upon the course of human affairs, and gives knowledge that may serve both for public and individual guidance. Viewed as an intellectual achievement, his undertaking is neither to be measured by the time consumed in its execution nor by the amount of labor involved, but by the nature and quality of the work itself. It was original throughout, was based upon the most comprehensive results of modern science, and was elaborated under the inexorable conditions of logical method. The development of a system of philosophy now is a very different thing from what it was in earlier times. Plato spun a system of thought before speculation was yet curbed by the knowledge of Nature; Spencer has constructed a philosophy out of the inflexible materials furnished in all the fields of modern investigation. His system is not a digest, but an organon; not merely an analytic dissection, but a grand synthetic construction; not a science, but a coördination of the sciences; not a metaphysical elaboration, but a positive body of doctrine conforming to verifiable facts, and based upon the most comprehensive principle of Nature yet arrived at by the human mind.

But no recognition of the greatness of Mr. Spencer's intellectual work will do him justice. There is a moral sublimity in his self-sacrificing career which is not to be neglected in making up the estimate of his character. As remarked by M. Laugel: "If Mr. Spencer, with his talents, his fertility of genius, and the almost encyclopedic variety of knowledge, of which his writings furnish the proof, had chosen to follow the beaten path, nothing would have been more easy than for him to secure all those honors of which English Society is so prodigal to those who serve her as she wishes to be served. He preferred, however, with a noble and touching self-denial, to put up with poverty, and, what is still more difficult, with obscurity." In advance of his generation and working against the powerful current of its prejudices, with broken health, without pecuniary resources, and depending upon promises of support that were but very partially redeemed, with an intrepidity that was not wanting in heroism, he entered upon the most formidable intellectual project that was ever undertaken by any single mind. One would think that it should have commanded the sympathy of the generous, and the cordial approval if not the kindly coöperation of all who appreciate courageous and noble endeavor; but, unhappily, a discriminating appreciation of genuine work is not over-abundant in these times, and, in the accomplishment of a task which I believe future generations will regard as the most memorable achievement of this fruitful age, Mr. Spencer has had but stinted encouragement and a very shabby support. In answer to the question, why his contemporaries have been so unappreciative, much might be said, but I will here confine myself to one or two suggestions.

In the first place, Mr. Spencer's work has been done under circumstances peculiarly unfavorable to the recognition of his rights as an original and independent thinker. Of the twenty-five articles prepared in the most active period of his life, and published between 1852 and 1860, which, as I have shown, are important contributions toward the development of the doctrine of Evolution in its various phases, most, if not all, appeared anonymously. They were printed in the different leading reviews, and many of them attracted marked attention at the time; but their author was unknown, and, of course, lost the advantage of having his ideas accredited to him. Up to the time when he had matured his system of thought, and was ready to enter upon its formal publication, he had been giving it out in fragments, as its several aspects had taken shape in his own mind. His articles, many of which were republished in this country, thus went far toward familiarizing the public mind with the general conception of Evolution, so that he was actually preparing his readers to discredit his subsequent claims to his own views, which, being reproduced and further diffused by others, were regarded as belonging to the common stock of current ideas. So far did this go, that he was ultimately exposed to the imputation of plagiarism for the restatement of opinions that he had first put forth, but which other men had appropriated and sent out as their own. Nor was the case much helped when he began to publish his System of Philosophy to subscribers, for so limited was its distribution that it might almost have been said that it was "printed for private circulation." Moreover, being the owner of his own works, the interests of publishers were not enlisted in their diffusion; while the assaults of the press were so malignant, and their representations so false, that for years he was constrained to withhold his series from the periodicals. All this was favorable to misconception, and left Mr. Spencer much at the mercy of dishonest authorship and unscrupulous criticism.

Again, it must be recognized that there were difficulties in appreciating his work which arose from its nature and extent. While a scientific discovery, or a single definite doctrine, is readily apprehended because the impression it makes is narrow and sharp, an extensive system of principles, which it requires power to grasp and time to master, can only be imperfectly received by the general mind. The very greatness of Mr. Spencer's work was thus an impediment to its recognition; and this, too, it must be acknowledged, on the part even of men of science. In the scientific world, the accumulation of facts has outstripped the work of valid generalization. For, while men of moderate ability can observe, experiment, and multiply details in special departments, it requires men of breadth to arrange them into groups, to educe principles and arrive at comprehensive laws. The great mass of scientific specialists, confined to their departments, and little trained to the work of generalization, are apt to regard lightly

the logical processes of science, and to decry mere theorizing and speculation. They forget that facts of themselves are not science, and only become so by being placed in true relations, and that the function of the thinker is therefore supreme; while the work of organizing facts and establishing general truths is, after all, just as much a specialty as that of observation or experiment in any branches of inquiry. The prevalence of these narrow views has been unfavorable to the recognition of Mr. Spencer's work by a large class of the cultivators of science; and the more so, as he has been mainly occupied in the highest spheres of generalization. For this reason it is only by the comparatively small number of scientific men, who possess marked philosophic power, that his labors have been justly appreciated.

But, while considerations of this kind are not to be overlooked in assigning the responsibilities of criticism, neither are they to be construed into excuses for prejudiced opinions, or crude and hasty judgments. It is the business of critics to inform themselves on important matters of which they speak, or to hold their peace. And, where there is peculiar difficulty or liability to error, they are all the more bound to caution, and to refrain from injurious interpretations. Reverting, now, to the criticisms cited at the outset of this discussion as typical of a class, we are prepared to rate them at what they are worth.

From what has been stated, I think it will be sufficiently evident that Mr. Spencer is no follower of Comte, Darwin, or any other man, and that he has pursued his own independent course in his own way. As to M. Taine's statement that "Mr. Spencer has the merit of extending to the phenomena of Nature and of mind" Mr. Darwin's principle of Natural Selection, the facts given show how mistaken was his view of the case. Strange to say, M. Taine, who claims to be a psychologist, puts forth this idea in a review of Mr. Spencer's "Principles of Psychology," a work which treated the subject of mind throughout, and for the first time from the point of view of Evolution, and this years before Mr. Darwin had published a word upon the subject.

As this error of M. Taine is frequently repeated,[1] and indicates a gross misapprehension of the subject, it is desirable to add a word or two regarding Mr. Darwin's relation to the question. While he has contributed immensely toward the extension and establishment of a theory of organic development, he has never made even an attempt to elucidate the law of Evolution as a general principle of Nature. His works do not treat of this problem at all, and nothing has tended

[1] Another example of it has just been furnished by the *Saturday Review*, which, in commenting upon Prof. Tyndall's late address, remarks: "What Darwin has done for physiology, Spencer would do for psychology by applying to the nervous system particularly the principles which his teacher (!) has already enunciated for the physical system generally."

more to the popular confusion of the subject than the notion that "Darwinism" and Evolution are the same thing. Mr. Darwin's fame rests chiefly upon the skill and perseverance with which he has worked out a single principle in its bearing upon the progressive diversity of organic life. The competitions of Nature leading to a struggle for existence, and that consequent winnowing which Mr. Darwin calls "Natural Selection," and Mr. Spencer calls "Survival of the Fittest," were recognized before Mr. Darwin's time: what he did, as I have before explained, was to show how this principle may aid in giving rise to new species from preëxisting species. But this principle is secondary and derivative, and its operation may be traced, as Mr. Darwin has traced it, without going back to those primary forces, the resolution of which constitutes the radical problem of Evolution.

The principle which Mr. Darwin promulgated is a part of the great theory, and it has a philosophic importance, exactly in proportion to the validity of that larger system of doctrine to which it is tributary as an element. Not only has Mr. Darwin never taken up the question of Evolution from a scientific point of view, but it was not his aim to explain even the evolution of species in terms of ultimate principles, as a part of the universal transformation—that is, in terms of the redistribution of matter and motion; for it is in this way that all proximate principles, including Natural Selection, have to be expressed before the final interpretation is reached. This mode of dealing with the subject, the only thoroughly scientific method of its treatment, belongs to Mr. Spencer alone. As to his following Mr. Darwin, we have already seen that, two years before the "Origin of Species" was published, Mr. Spencer had reached the proof of Evolution as a universal law; had traced its dependence upon the principle of the Conservation of Force; had resolved it into its ultimate dynamical factors; had worked out many of its important features; had made it the basis of a system of Philosophy; and had shown that it furnishes a new starting-point for the scientific interpretation of human affairs.

Colonel Higginson imputes to Mr. Spencer, as a weakness, the propensity to write on a great number of subjects; I have shown, on the contrary, that he has been compelled to write upon many subjects from logical necessity, and has done so in unswerving devotion to the development of one class of ideas. It will be seen that he is now upon the same identical track of thought which he opened in his youth, to which he has consecrated his life, and which he has made his own. Thirty-two years ago he began to study the social condition and relations of men from the scientific point of view, and to treat of human society as a sphere of natural law. After eight years he published a treatise upon the question, which, although in advance of the times, only served to convince its author that the investigation was barely begun, and that, before any adequate social science was possible, the

whole subject required to be more deeply grounded in the knowledge of Nature. Upon that deeper study of Nature he then entered, and, after twenty-four years of steady and systematic preparation, the problems of Social Statics are resumed in the "Principles of Sociology." If so prolonged and inflexible a course of original inquiry, yielding results which are felt in the highest spheres of thought, are suggestive of "a weakness," we should be glad to be furnished with the examples which embody Colonel Higginson's conception of strength in mental character. As to the declaration that it seems absurd to attribute to Mr. Spencer any vast enlargement or further generalization of the modern doctrine of Evolution, we leave its author to reconcile his opinion with the fact that the System of Psychology, which first extended the principle of Evolution to the sphere of mind, had been nine years before the world—the conception of universal Evolution had been formulated and promulgated four years, and "First Principles" had been for some time published, when this statement was made.

Mr. Emerson's criticism of Spencer is summary and decisive, as becomes a man who has gone to the bottom of a subject. Reticent and mystical no longer, he plumps out his opinion, when interviewed, with all the confidence of one who knows what he is talking about. Into the pantheon of immortals, arranged for the reporter of Frank Leslie's newspaper, none may enter but star-writers, and Mr. Spencer is only a "stock-writer." We may, however, presume that Mr. Emerson has here followed his transcendental lights, as there are many who will insist that he is not for a moment to be suspected of having ever read Mr. Spencer's books; though it will still remain a mystery how he has so skillfully contrived to make his statement as exactly wrong as it could be made. It will, probably, matter little to Mr. Spencer what Mr. Emerson thinks of his position, as it can matter nothing to Mr. Emerson what we think of his judgment; but it should matter a good deal to him that he do not lend the influence of his eminent name to the perpetration of injustice. Speaking in the light of the facts here sketched, we say that Mr. Emerson will search the annals of authorship in vain to find an instance in which his epithet would be more grossly misapplied. And we will do him the justice to say that in other days he has taught us a more generous lesson in regard to what is due from the manly and liberal-minded to the heroic endeavors of noble and unrecognized men. Many of his admirers will recall with pleasure the following admirable passage: "What is the scholar, what is the man *for*, but for hospitality to every new thought of his time? Have you leisure, power, property, friends? you shall be the asylum of every new thought, every unproved opinion, every untried project, which proceeds out of good-will and honest seeking. All the newspapers, all the tongues of to-day, will, of course, at first defame what is noble; but you, who hold not of to-day, not of the times, but

of the everlasting, are to stand for it; and the highest compliment man ever receives from Heaven is the sending to him its disguised and discredited angels." This is a grand exhortation, and has, no doubt, thrilled many a reader with enthusiasm for the rising thoughts of his time. But the difficulty still remains, how to identify the celestial messengers! Such are the eccentricities of human judgment, that the sympathy which Mr. Emerson invokes is as likely to be given to the worthless as to the worthy. And what shall we say about the duty of common mortals respecting the "disguised and discredited angels," when the Seer himself snubs the author of "First Principles" as a "stock-writer," and says to the author of that unclean imposture—"Leaves of Grass"—"I greet you at the beginning of a great career?"

HUMAN LOCOMOTION.

THE movements executed by animals in transporting themselves from place to place have long engaged the attention of observers; and, as animals which travel on the land are more easily got at than those which frequent the sea and the air, it is the motions of such that we know most about. Yet much remains to be learned of the modes of progression of even the most familiar of these; and not a little probably will have to be unlearned that recent investigations have shown to be erroneous.

At first sight, the operations of walking and running, as displayed by both two-legged and four-legged creatures, may appear simple enough, but all attempts to analyze and explain them have shown that in reality they are very complex, so that there has arisen a wide diversity of opinion concerning their real nature. These disagreements among the investigators of the subject can only be accounted for on the principle of the insufficiency of the means at their command for complete investigation; and the confusion has been further increased by the difficulty of expressing in words the rhythm, duration, and phases of the rapid and complex movements involved.

Prof. E. J. Marey, of the College of France, a skillful physiologist, and the inventor of the various delicate mechanical appliances for tracing and registering obscure animal motions, has contributed to the "International Scientific Series" a work entitled "Animal Mechanism," in which the subject of terrestrial locomotion, as typified in man and in the horse, is fully treated. Prof. Marey has devised an apparatus which, applied to the extremities of a moving animal, enables each limb to write out a description, or make a picture of its own actions, so that the duration and phases of its movements, its periods of rest, and the relations of these to the corresponding features in the motions

of the other limbs, may be seen at a glance. A description of this apparatus, and its mode of operation, with the results that it gives when applied to man, will first engage our attention.

For the sake of clearness, the machine may be described as con-

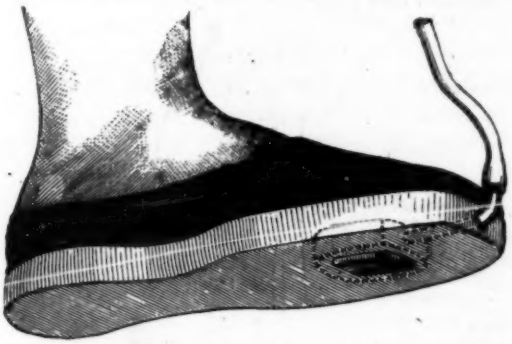

FIG. 1.—EXPERIMENTAL SHOE, INTENDED TO SHOW THE PRESSURE OF THE FOOT ON THE GROUND, WITH ITS DURATION AND ITS PHASES.

sisting of two parts, one of which is applied to the limb, and is called the *experimental shoe*, while the other is carried in the hand of the operator, and is simply a registering instrument, connected with the shoe by an India-rubber tube. The experimental shoe is made by

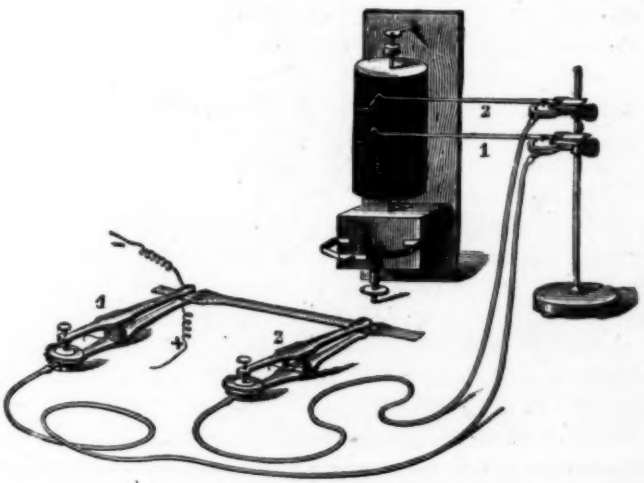

FIG. 2.—DISPOSITION OF A BUNDLE OF MUSCLE BETWEEN TWO PAIRS OF MYOGRAPHICAL CLIPS. Clip No. 1 holds the electric excitators of the muscle. A wave is represented at the moment when it has just crossed each of the clips.

fixing under the sole of an ordinary shoe, with heated gutta-percha, a strong sole of India-rubber about five-eighths of an inch thick. Within this sole there is an air-chamber, which, in Fig. 1, is represented by dotted lines.

This chamber, having upon it a small piece of projecting wood, is compressed at the moment the foot exerts its pressure on the ground. The air expelled from this cavity escapes by the tube, actuating the recording instrument in the hand of the experimenter, causing it to register the duration and phases of the pressure of the foot.

FIG. 3.—RUNNER PROVIDED WITH THE APPARATUS INTENDED TO REGISTER HIS DIFFERENT PACES.

The registering instrument consists of a little drum, with its upper side formed of some elastic membrane. On this membrane rests a lever having the point of its long arm in contact with the surface of a revolving cylinder, which may be made to move at any required rate, and which carries a slip of paper prepared to receive the tracings. Fig. 2 is a representation of this instrument as employed in registering

the transverse dilatation of muscular fibre in the process of contraction. If we substitute in this figure an experimental shoe for each of the myographical clips, 1 and 2, we shall have the arrangement of the apparatus necessary for the study of *footsteps* or *impacts* of the foot on the ground.

The entire apparatus, as adjusted to the person of the operator, is seen in Fig. 3. The piece of machinery on the head will be described when we come to speak of the movements communicated to the trunk by the actions of the legs.

To understand the indications which the working of the apparatus gives, the reader is referred to Fig. 4, which has been furnished by an experiment in walking. Two tracings are given by the intermittent pressure of the feet on the ground. The full line *D* corresponds with the right foot; the dotted line *G* with the left. The lines are read from left to right.

Knowing the arrangement of the apparatus, we can understand that each impact of the foot on the ground will be represented by the elevated part of the corresponding curve. The pressure of the foot on the ground compresses the India-rubber sole and diminishes the capacity of the included air-chamber; a part of the contained air escapes by the connecting tube, and passes into the registering drum. The elastic side of the latter is thus elevated, carrying up the point of the lever, which in turn leaves the mark of its movement on the paper carried by the revolving cylinder. Were the lever to remain undisturbed, it would simply make an horizontal line running round the cylinder; but, with the apparatus in use, each impact of the foot lifts the pen-point of the lever, thus giving the curves traced in the figure. It will be seen that the pressure of the right foot commences at the moment when that of the left begins to decrease; and that in all the

FIG. 4.—TRACINGS OF THE IMPACT AND THE RISE OF THE TWO FEET IN OUR ORDINARY WALK.

tracings there is an alternation between the impacts of the two feet. The period of *support* of each foot is shown by an horizontal line which joins the minima of two successive curves. The impacts of the right and left feet are seen to have the same duration, showing that the weight of the body passes alternately from one foot to the other. It would not be the same in respect to a lame person; lameness corresponds essentially with the inequality of the impacts of the two feet.

The curves traced by walking may also furnish the measure of the effort exerted by the foot upon the ground. The experimental shoes

constitute a sort of dynameter of pressure; they compress the drum less or more according to the effort they exert, and consequently transmit to the registering lever more or less extensive movements. In order to estimate, according to the elevation of the curve, the pressure exerted by the foot, we must substitute for the weight of the body a certain number of pounds. We see thus that, if the weight of the body (150 pounds for example) is sufficient to raise the lever to the height it attains at the commencement of each curve, an additional weight will be required to raise it to the maximum elevation which it attains toward the end of its period of pressure. This proves that, in walking, the pressure of the foot on the ground is not only equal to the weight of the body which the foot sustains, but that a greater effort is produced at a given moment in order to elevate and move the body forward. This additional effort, in a man of average weight, is estimated at about forty pounds, and it is much greater in running and leaping.

There are certain oscillations of the body, both vertical and horizontal, produced by the actions of the legs, which M. Marey has carefully traced, but which, owing to their extreme complexity, are difficult to explain. We shall therefore pass them with only a glance, referring the reader to the work itself for details. With each step there is an up-and-down movement of the body, which varies with the length of the step and the rapidity of the pace. In ordinary walking it has an amplitude of from half to three-quarters of an inch. The maximum of these vertical oscillations is constant, and occurs during the pressure of the foot upon the ground, at the moment when the leg is brought into a straight position. The minima, and consequently the extent of the oscillations, will be determined by the length of the step; the longer the step the greater the obliquity of the legs, and, of

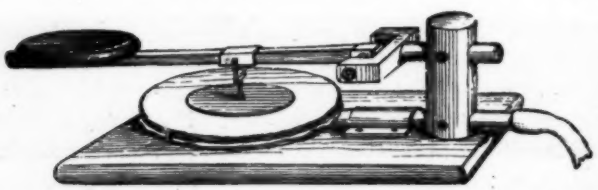

FIG. 5.—INSTRUMENT TO REGISTER THE VERTICAL REACTIONS DURING THE VARIOUS PACES.

course, the greater the lowering of the trunk. Put in another form, it amounts to this: in ordinary walking, the body does not rise above the line of its greatest height when standing still, and the distance which it sinks below this line will increase as the length of the step increases.

The instrument by which M. Marey obtains the tracings of these vertical reactions is represented in Fig. 5.

It is an experimental lever-drum, fixed on a piece of wood, which is fastened with moulding-wax on the head of the experimenter, as

seen in Fig. 3. The drum is provided with a piece of lead placed at the extremity of its lever; this mass acts by its *inertia.* While the body oscillates vertically, the mass of lead resists these movements, and causes the membrane of the drum to sink when the body rises, and to rise when the body descends. From these alternate actions a current of air results, which, transmitted by a tube to a registering lever, shows by a curve the oscillatory movements of the body.

A complete horizontal oscillation occupies the time of two steps, and, consequently, of two vertical oscillations. The body is carried toward the right side, at the moment of the maximum of elevation, which corresponds with the middle of the pressure on the right foot, and toward the left at the middle of the pressure on the left foot. This lateral swaying of the trunk is the consequence of the alternate passage of the body into a position sensibly vertical over each foot.

The body is advancing at every moment during the step, but at some parts of it more rapidly than at others. The greatest rapidity of advance is at the end of the pressure of the foot.

With this brief sketch of the movements of the limbs and body in walking, and of the apparatus employed by M. Marey for studying these movements, we are prepared to consider the different paces common to man.

FIG. 6.—TRACING PRODUCED BY WALKING UP-STAIRS.—*D*, tracing of the pressure and rise of the right foot (full line); *G*, tracing of the left foot (dotted line).

In walking, the body does not leave the ground, the footsteps follow each other without any interval, and the weight of the body passes alternately from one foot to the other. The tracings in Fig. 4, obtained by walking on a level surface, illustrate these points. There are exceptions, however, to this definition. For example, in mounting a staircase it will be observed that the step-curves encroach on each other (Fig. 6), showing that each foot is still pressing on its support when the other has already planted itself on the next step. Besides this, it is at the time of this double pressure that the lower foot exerts its maximum force; it is at this moment, in fact, that the work is produced which raises the body to the whole height of a step. Nothing like this is observed in the descent of a staircase; the step-curves cease to encroach on each other, following one another very much as in ordinary walking on level ground.

Running, though more rapid than walking, consists like it in alternate treads of the two feet, whose step-curves follow each other at equal intervals; but it presents this difference, that in running the

body leaves the ground for an instant at each step. Fig. 7 shows the principal characters of this mode of progression. The pressures of the feet are more energetic than in walking; in fact, they not only sustain the weight of the body, but impel it with a certain speed both upward and forward. It is clear that, to give a mass a rising motion, a greater effort must be exerted than would be sufficient simply to sustain it. The duration of the pressures on the ground is less than in walking; this brevity is proportional to the energy with which the feet tread on the ground. These two elements—force and brevity of pressure—increase generally with the speed at which a person runs. The essen-

FIG. 7.—TRACING PRODUCED BY RUNNING (IN MAN).—*D* (curve formed by a full line), impact and rise of right foot; *G* (dotted line), action of the left foot; *O*, oscillations and vertical reactions of the body.

tial character of running is *the time of suspension*, during which the body remains in the air between two foot-falls. Fig. 7 clearly shows the suspension by the interval which separates the descent of the curves of the right foot from the ascent of the curves of the left foot, and *vice versa*. The duration of the time of suspension appears to vary but little in an absolute manner; but, if we compare it with the speed of the runner, we see that the relative time occupied by this suspension increases with the speed of the course, for the duration of each tread diminishes in proportion to this speed. How is this suspension of the body, at each impulse of the foot, produced? We might at first think that it is the effect of a kind of leap in which the body is projected upward in so violent a manner, by the impulse of the feet, that it would describe in the air a curve, in the midst of which it would attain its maximum elevation from the ground. We may convince ourselves that such is not the case by reference to Fig. 7. The upper line (*O*) is a tracing of the vertical oscillations in running. It shows that the body executes each of its vertical elevations during the *downward pressure* of the foot, so that it begins to rise the moment the foot touches the ground; it attains its maximum elevation at the middle of the pressure of this foot, and begins to descend again in order to reach its minimum at the moment when one foot has just risen, and before the other has reached the ground. This relation of the vertical oscillations to the pressure of the feet shows plainly *that the time of suspension* does not depend on the fact that the body projected into the air has left the ground, but that the *legs have withdrawn from the ground*

by the effect of their flexion; and this takes place at the very moment when the body was at its greatest elevation.

Galloping, a gait that children in their amusements sometimes adopt, gives the tracings shown in Fig. 8. The tracings produced by leaping are shown in Fig. 9.

FIG. 8.—MAN GALLOPING WITH THE RIGHT FOOT FIRST.—Step-curves and reactions. There is an encroachment of one curve over the other, and then a suspension of the body. The curve *O*, which corresponds with the reactions, shows the effect of the two successive impulses exerted on the body by the feet.

Among the characters belonging to the various modes of progression, the rhythm of the impact of the feet is one of the most striking. The strokes of the feet upon the ground give rise to sounds the order of whose succession is sufficient for a person, with an ear accustomed to them, to recognize the kind of pace which produces them. In order to give the figure of each of these rhythms, Prof. Marey employs the musical notation, modified so as to furnish at the same time the notion of the duration of each pressure, that of the foot to which this pressure

FIG. 9.—LEAP ON TWO FEET AT ONCE (*D* AND *G*).—The line *R*, the curve of reactions, shows that the maximum of elevations corresponds with the middle of the pressure of the feet.

belongs, and also the length of time during which the body is suspended. This notation of rhythms is constructed in a very simple manner from the tracings furnished by the apparatus. Fig. 10 represents the curve which corresponds with the act of running in man. Below this figure let us draw two horizontal lines, 1 and 2; these will form the *staff* on which will be written this simple music, consisting only of two notes, which M. Marey calls *right-foot* and *left-foot*. From

the commencement of the ascending part of one step-curve belonging to the right foot we will let fall upon the staff a perpendicular (*a*); this line will determine the commencement of the pressure of the right foot. A perpendicular (*b*) let fall from the end of the curve will determine where the pressure of this foot ends. Between these two points let us trace a broad white line; it will express, by its length, the duration of the pressure of the right foot. A similar construction

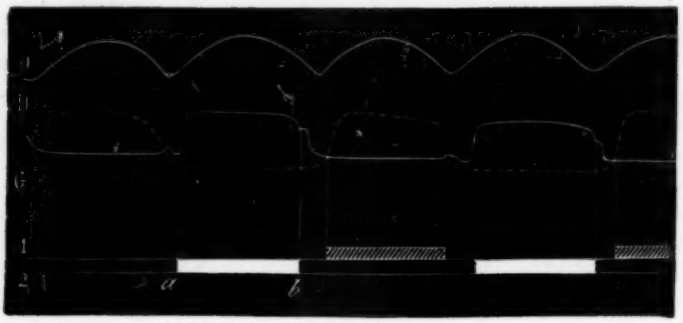

FIG. 10.

made on line 1, from the succeeding step-curve, will give the notation of the pressure of the left foot. The notations of the left foot have been shaded with oblique lines, to avoid confusion.

Between the pressure of the two feet there is found to be silence in the rhythm; that is to say, the expression of that instant of the course when the body is suspended above the ground.

If we note in this manner the rhythms of all the paces used by man, we shall obtain a synoptical table which will much facilitate the comparison of these varied rhythms. Fig. 11 represents the synop-

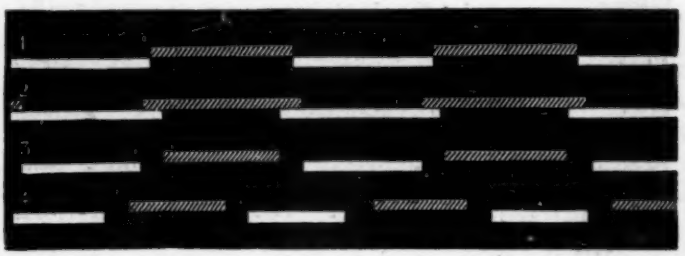

FIG. 11.—SYNOPTICAL NOTATION OF THE FOUR KINDS OF PROGRESSION USED BY MAN.

tical, of the four kinds of progression, or paces, which are regularly rhythmical, and in which the two feet act alternately. Line 1 represents the notation of the rhythm of the walking-pace. The pressure of the right foot upon the ground is represented by a thick white stroke, a sort of rectangle, the length of which corresponds with the

duration of the pressure. For the left foot there is a grayish rectangle shaded with oblique lines. These alternations of gray and white express by their succession that in walking the pressure of one foot succeeds the other, without allowing any interval between the two.

Line 2 is the notation which corresponds with the ascent of a staircase. It is seen that the strokes lap, or encroach on each other, and that, consequently, the body during an instant rests on both feet at once.

Line 3 corresponds with the rhythm of running. After a shorter pressure of the right foot than in the walking-pace, an interval is seen which corresponds with the suspension of the body; then a short pressure of the left foot followed by a fresh suspension, and so on continually.

Line 4 answers to a more rapid rate of running. It shows a shorter duration of the pressures, a longer time of the suspension of the body, and a more rapid succession of the various movements.

This method of representing the different modes of progression by the notation of their rhythms, though hardly necessary to make clear the simple paces of man, will greatly aid us in understanding the more complicated paces of the horse, which will be the subject of another article.

EDUCATED TO DEATH.[1]

A MOTHER'S STORY.

AT the age of fifteen Mary was a remarkably fine and healthy girl: she seemed to be safely over the critical period, and, till after that time, had never suffered as many girls do at the commencement of their womanhood. Her thinking powers were quick and vigorous, and she was the pride of her teachers and joy of her parents. Unlimited mental progress was laid out for her, and it seemed that there were to be no bounds to her acquirements.

She had then finished a good common-school education, at the best high-school, and had entered an institute for young ladies (a boarding-school) of the highest character. The curriculum of study

[1] From "The Building of a Brain," by Edward H. Clarke, M. D. The appearance of this narrative in Dr. Clarke's volume is thus explained by him in the following prefatory remarks:

"Last February I received a letter from a gentleman, personally a stranger to me, but well known as an accomplished scholar and writer, to the effect that the case of his daughter, who died less than a year previous, aged eighteen, would furnish an excellent illustration of the evil results of inappropriate methods of female education, and that he would be willing to have the history of her case published, if its publication would render any service to the cause of sound education. In reply to a request for the history which he had so kindly and unexpectedly offered to prepare, the following note was re-

there was comprehensive, and it required the closest application of an ambitious scholar to succeed.

One hour was allowed for walking and recreation during the day; and half of that hour could be spent, if the pupil desired to do so, in the music-room. As the months went on, I began to notice that her complexion, which had been pure rose-leaf, became almost transparent, and that the fresh blood left her cheeks: still she did not complain nor lose flesh, but said sometimes, if she could *sleep a week* she would enjoy it, and that it almost always happened, when she was unwell, she had the most to do, and the longest to stand. Her progress in her studies was wonderful; and it seems incredible to me now that we should have let her devote herself so entirely to them. Her musical talents were great, and they were under cultivation also: when she was seventeen she was the first soprano singer in the choir of the church to which she belonged.

At last I began to be alarmed at the remarkable flow whenever she was unwell, and at the frequent recurrence of the periodical function. I felt as if something should be done, and consulted our family physician as to what could be given her, and how this increased action could be stopped or diminished.

He prescribed iron as a tonic, but said that we should do nothing more; for that "every woman was a law unto herself," and, as long as nothing more serious occurred, she was to be let alone. This from a man who had daughters himself, and eminent in the profession! Never a word about rest, never a caution that she could overwork herself, and thus bring misery for the remainder of her life. She left school, in June of that year, with noble honors and an aching frame, and, after two months' vacation and rest, which seemed to do her a world of good, began in September another year of unremitting hard study. Loving and gratified parents, proud and expectant teachers, looked upon her as capable of accomplishing all that had ever been done by faithful students, and of advancing far beyond all who were in the graduating class with her.

Her teachers were as kind as any could have been. I think the fault was in the system that requires so many hours of study, no matter what the condition of the pupil may be.

ceived, which forms an appropriate and sufficient preface to the sad account that follows it:

'*March* 30, 1874.

'DEAR SIR: The inclosed statement is from the pen of my wife. If it can serve the right, you are at liberty to make use of it—in whole or in part, in the language in which it now stands, or in modified or entirely different language—as in your judgment may seem best. You, of course, will not give names, certainly not in full.

'Very truly, ——— ———.'

"It is proper to say that, except a few slight verbal alterations, which the writer herself would probably have made if she had corrected the proofs of her manuscript, no changes have been ventured upon in the language by which a mother presents the instructive lesson of her daughter's method of education, and its result."

As an instance, twenty-five questions were given her to be answered. She was seated at a table, without books, from 10 A. M. till 8 P. M., ceaselessly *thinking* and writing; and the twenty-five questions in classical literature were faultlessly answered, and that, too, at a time when, had I known what I know now, she should have been resting on her bed.

Her father, to whom the paper was shown for his approval, wrote on the margin: "It seems to me that the task imposed here was a *great one, indeed;* but it has been performed with good success." I do not for a moment mean to find fault with her teachers, for kinder, more interested ones no pupil ever had; and the delight that a teacher derives from a painstaking and appreciative pupil cannot be understood by those unused to teaching.

While the dear child was meeting our utmost requirements as a scholar, the foundations of her life were being sapped away.

In May, 1872, a little more than two weeks before the June commencement, she was taken with fearful sickness and severe chills, just after one of the hæmorrhages that came every three weeks regularly. Our doctor was called, and the first thing she said to him was: "Doctor, I must not be sick now. I cannot afford the time. I *must* be well for commencement." For four days she suffered very much, but quinine and all sorts of tonics brought her up; and the two weeks that should have been taken to get well in were spent in study, study, study. All the examinations were passed successfully, even brilliantly, and she was graduated with all the honors of the institution. Oh, how proud we were of her! and when she came home, frail and weak as a wilted flower, we said that she should have a long rest, and every comfort that we could give her.

All summer she remained in the Highlands of the Hudson; yet, when autumn came, she was not as well as we thought she ought to be, though very much improved with regard to the monthly turns, they recurring at right times now.

In September she commenced studying again; her French and music were continued, so that she might become still more accomplished in those branches, and lectures on rhetoric and moral philosophy were attended also.

The habit of studying was so strong upon her that she could not give it up. Now came swelling of the joints and fingers, and the old trouble, all of which she would have kept to herself if she could have done so; but I was so anxious about her that I ascertained her condition, went to the doctor again, and begged him to tell me what to do that would stop the weakening periodical disturbance, as I was persuaded that was the cause of her trouble. He said she had inflammatory rheumatism, and prescribed *soda*. But I was not to do any thing for the other matter, and, against my own convictions, I let things take their course. Oh, if he had said, "Take her home, and

stop her studying!" Armed with such authority, I should have done it, and how do we know but she might have been with us now if I had done so?

But, she worked on till the 25th of December. Then she came home, and said decidedly she would study no more till she was *well*.

We were rejoiced at her decision; for, although we were anxious that her education should be completed and thorough, we had felt for a long time that her health was becoming impaired. Still we were sure she had a good constitution, and thought that would carry her through. She did not grow thin, but *stout* and *pale*, and such a transparent pallor, that, now I think of it, I wonder all who looked at her did not see that her blood was turning to water. Her sweet and lovely soul was so uncomplaining, and her smile always so bright, that we never for a moment thought *she could* fade and die.

She brightened up somewhat for the next month, but still did not "get well." About the last of January her limbs swelled so much that, in haste, I rushed to the doctor. Then he said her kidneys were congested, and that Bright's fatal disease was her malady. All that despairing love could do was done *now*. In five short weeks we laid her in Greenwood. Whatever was the form of the disease from which she suffered, I am convinced that what she did have was brought on by incessant study when she should have rested, and that it was fixed at the time that she got the severe chills—in May, 1871.

She was by no means a frail girl when she entered the institute. She was tall, finely formed, with a full, broad chest, and musical organs of great compass. Her bust was not flat, neither was it as full as it might have been. Her features were not too large. She had brown eyes, brown hair, a very sweet and pleasing face. With every indication at first of strength and a good constitution, she fell at last a victim to want of sense in parents and teachers, and—shall I say?—physician too.

THE RESPIRATION OF PLANTS.

By ÉMILE ALGLAVE.

TRANSLATED FROM THE REVUE SCIENTIFIQUE, BY J. FITZGERALD, A. M.

I.

THE functional contrast between the two organic worlds of plants and animals was, till lately, the groundwork of all scientific speculations. The labors of the most illustrious men of science had confirmed this theory; and then, too, it was in accord with all the known facts.

Plants, it was held, grow in order to supply animals with food, and to make life possible for them; the activities of vegetal life produced

the immediate principles of food, and animal life destroyed them; the various excretions of animal life were the natural ferment of vegetal life, and the latter purified the air, contaminated by animal emanations; finally, that function of the organism which is most continuous, namely, respiration, consisted, in animals, in the absorption of oxygen, followed by exhalation of carbonic acid, while in plants it consisted in the absorption of carbonic acid, followed by exhalation of oxygen. In this way the respiration of plants would decompose the carbonic acid produced by the respiration of animals, thus preserving the normal constitution of the atmosphere.

The famous experiments of Claude Bernard on the glycogenic function of the liver, revealing, as they did, the formation in the liver of animals of one of the most important of these immediate principles, to wit, sugar, delivered on this apparently philosophic and well-established theory a severe blow, from which it could not recover. Soon, a very different theory, one no less philosophic in its general form, was proposed; and this theory was so bound up with the tendencies of modern science and philosophy, that its success was assured from the outset. In place of the harmonic contrast of the two kingdoms, we have now the functional unity of living Nature. Our readers have not forgotten the lectures delivered during several years by Claude Bernard, at the Paris Museum of Natural History, in which he has developed this grand conception. Instead of comparing together animals and plants, pointing out their differences, as the usual course has been, Bernard enumerates their resemblances; and this simple change in the point of view at once gives to the *ensemble* of the facts a very different meaning.

But, still there appear to remain some fundamental differences, chiefly with regard to respiration.

Since the date of the early researches, which made out the respiration of plants to be an exhalation of oxygen resulting from the decomposition of the carbonic acid of the atmosphere, sundry not very recent experiments have to a certain extent limited the bearings of the original conclusions. It was soon discovered that this mode of respiration is subordinated to the action of solar light, and that it occurs only in the leaves and in the green portions of the plant, the coloration being due to the presence of a special principle called chlorophyll; and thus the chlorophyll came to be regarded as the organ, the essential agent of plant-respiration. Next, the discovery was made that the flowers of a color different from green, and even the green portions themselves when placed in the dark, not only do not absorb carbonic acid out of the atmosphere, and then exhale the oxygen of that acid; they go further, and do the very opposite, absorbing oxygen and giving up carbonic acid, just as animals do.

Hence the assignment to plants of a second mode of respiration, known as *nocturnal*, as opposed to the other mode, called the *diurnal*

respiration. But, notwithstanding the discovery of a number of facts which tended to enlarge the province of this so-called nocturnal respiration, it was far from attaining the importance of the diurnal, which all the botanists held to be the true respiration of plants, and which, as compared with the other mode, clearly deserved this distinction, owing to the number, the duration, and the extension of the phenomena which it represented.

One might wonder at this strange duality of respirations in a single being—respirations that were antagonistic in their very essence; especially might one ask how plants could be deprived, during one-half of their life, of that physiological function, the unceasing performance of which would seem to be the most indispensable of all, to wit, the respiratory function—for this was held to be identical with the diurnal respiration; it might even be observed that certain plants, grown in the dark, perform this function very seldom; but, for all that, the facts all seemed to require the acceptance of the current theory.

These preliminary remarks will enable the reader fully to see the importance of the researches recently explained to the Lille Society of Sciences, by M. Corenwinder, of whose paper we propose to give a summary. The author, who has for twenty years pursued in one direction his studies of vegetal physiology, has proved that the nocturnal respiration of plants, though supposed to be exceptional, is in fact perfectly continuous, and constitutes their only true respiration. What hitherto has been called diurnal respiration, viz., the absorption of carbonic acid, the seat of which is the chlorophyll, instead of being the true respiratory phenomenon, is a phenomenon of assimilation and digestion, as pointed out by Claude Bernard. Plants and animals respire both in the same way. This is the grand fact, the proofs of which are given by Corenwinder.

II.

Buds, young shoots, and nascent leaves, discharge a function hitherto insufficiently considered, but yet this function is of such a nature as to elucidate the most important laws of vegetal physiology. It may be readily shown by very simple experiments that, in this first period, and *for a certain length of time*, plants absorb oxygen *unmistakably and uninterruptedly*, exhaling carbonic acid. Nor is it only in the dark that they discharge this function; indeed, it is not very apparent during the night, when the weather is cold, as is often the case in spring. It is during the day, and when the sunlight is strongest, that this function becomes characteristic, and especially when the temperature is rising.

This is easily shown by placing delicate plants, gathered in the early stages of their growth, under a close bell-glass, connected with a receiver holding concentrated baryta-water, the receiver in turn being

connected with an aspirator, which causes the air in contact with the plant to pass gently over the baryta solution. For instance, take a freshly-opened bud of the chestnut, and presently, or at least after a very little while, there is seen to form, in the daylight, a deposit of carbonate of baryta, and this increases very rapidly. Of course, care must be taken to deprive the air of its carbonic acid before it is admitted into the bell-glass.

A very simple experiment will make it plain that, in the course of this first period, the nascent leaves absorb to an appreciable extent the oxygen of the air both day and night. We have only to place the plant in a small bell-glass containing common air, the mouth of the vessel being stopped by means of a solution of caustic potash in a saucer. Soon we observe the solution rising in the bell-glass, and standing still at a certain point, which it never goes beyond. (Care must be taken not to allow the alkaline liquid to touch the petioles of the leaves.) If we now examine the elastic fluid which remains unabsorbed, we find that it contains nothing but nitrogen. In this operation the oxygen is inhaled by the leaves, which transform that gas into carbonic acid; this they expire in variable proportions according to their age, and it is absorbed by the caustic-potash solution.

But this power of absorbing oxygen and of exhaling carbonic acid in the daytime, while very evident at the instant of the opening out of the buds, becomes sensibly less pronounced, according as the leaves grow, and, as a general rule, this phenomenon ceases to be presented after these organs have attained their normal development. Hence, it is certain that plants, in their earlier stages, respire after the manner of animals, absorbing oxygen and exhaling carbonic acid. These physiological facts were demonstrated by M. Corenwinder, in a memoir published in 1866 by the Société des Sciences of Lille.

III.

It is not alone young plants just produced from the seed or from the bud in the spring that offer these characters: all foliaceous organs, while young, tender, and injected with nitrogenized materials, and just beginning to derive their nourishment from the carbon of the atmosphere, sensibly exhale carbonic acid in the daytime. If we observe the young branches which, during summer, grow on trees of persistent foliage, the *Laurocerasus*, for example, we find that, in these new growths, the phenomenon of respiration predominates: they exhale sensibly carbonic acid in the daytime.

But, if we place under a closed bell-glass an entire branch bearing leaves of the current and of the preceding year, collecting the air that has been in contact with them in a receiver holding baryta-water, and provided with an aspirator, we find that the result varies according to the relative quantities of new and old leaves. If the latter are in excess, they absorb the carbonic acid exhaled by the former, and the

baryta-water remains clear, but it grows turbid when the new leaves predominate.

If the experiment be made at the period when all the leaves of the current year have attained their adult age, the branch of *Laurocerasus* gives out no carbonic acid while exposed to light, provided the light is not very feeble.

The point at which plants cease perceptibly to give out carbonic acid in the daytime varies widely according to the species. Corenwinder has found some which exhibit this property for a long time, while others lose it very early. In the first category we may class a perennial plant common in our gardens, *Diclitra spectabilis*, and in the second the young leaves of the beet.

The cause of this peculiarity cannot at present be assigned; certain it is, however, that it largely depends on external circumstances, heat, for instance, which quickens all the chemical actions of oxygen, or the intensity of the light which promotes the assimilation of the carbon. But the special nature of the plant also plays a part. Hence we must not jump at conclusions after one of these experiments, if we would avoid setting up artificial laws with many exceptions.

It was at first difficult to account *a priori* for the fact of this property of nascent plants constantly exhaling carbonic acid, being at the outset very patent, and then diminishing in intensity as they grow, and finally disappearing. But experiments of another kind, described eight years ago by M. Corenwinder, put him on the track of this phenomenon, and gave him a plausible explanation of it.

Adopting the same processes which enabled Bonnet, Ingenhousz, and Sennebier, to lay the foundations of plant physiology, he placed buds and young stems bearing new leaves in bell-glasses filled with spring-water containing bicarbonate of lime or in water charged with carbonic acid, and then exposed them to the sun. As was to be expected, the leaves were soon covered with bubbles, and gave off oxygen; and this is the case even with leaves whose evolution is not yet complete. Hence it is plain that, from the earliest period of their life, plants decompose the carbonic acid of the atmosphere and assimilate its carbon.

Thus the foregoing experiments prove two facts which seem to be contradictory, and which, nevertheless, are simultaneous: 1. Inhalation of oxygen, accompanied with emission of carbonic acid; 2. Absorption of carbonic acid, leading to a discharge of oxygen. Hence, in young plants, there is simultaneity of the two modes of respiration commonly attributed to older plants; but, in the latter, these two modes have different conditions or different organs. This was the starting-point, and it had to be made clear by means of accurate research.

IV.

As we now see, the plant begins, in the early stages of its life, to respire as the animal does, absorbing oxygen, and exhaling carbonic

acid. But we have still to inquire why it is that the exhalation of carbonic acid gradually diminishes as the leaves grow in size. This is the great point to settle. Inasmuch as the respiratory organ grows in vitality and in size, it looks as though the respiration ought to become more active, and consequently augment the exhalation of carbonic acid, if this latter process is the respiration.

In order to solve this problem, M. Corenwinder judged it necessary to investigate very closely the variations occurring in the chemical composition of leaves during their vegetation. For this purpose he has made numerous researches, whereof we will describe two experiments made during the summer of 1873, one upon a white lilac, the other upon a maple with fine green leaves. These occupy a good, airy site in the author's garden, near the city of Lille.

M. Corenwinder gathered leaves of these plants at suitable intervals, from April 15th till October 31st, analyzing them afterward to determine the amount of water, nitrogenized substances, ash, and ternary compounds, they respectively contained. In sundry cases, at the most characteristic periods, the proportion of phosphoric acid contained in the ash was accurately weighed.

As every one knows, water forms a considerable portion of the substance of leaves, as much as four-fifths. As a rule, this proportion becomes less as the season advances, and the leaves grow older, but the diminution is not regular. As M. Corenwinder has shown, it needs but to rain for a little while to very sensibly raise again the proportion of water in leaves. These variations in the water of vegetation of leaves make it difficult to compare the other elements which they contain, and hide the relative increase or decrease of each of these elements. De Saussure evaded this difficulty by calculating the leaves in the dry state, and then determining what would be the relative proportions per cent. of the various elements in each leaf, if really deprived of all its water. M. Corenwinder adopts the same course. Having given in full the results of his two series of experiments, he condenses them in the following tables, which enable us easily to follow the evolution of each of the groups of elements in the leaf:

LEAVES OF COMMON LILAC.

1873.	REMARKS.	Nitrogenized Matter.	Carbonaceous Matter.	Ash.
April 15	Leaves small	27.87	67.71	4.42
" 18	" larger, flower-buds just appearing	23.36	71.45	5.19
" 21	" still larger, flower-buds developed	18.00	77.04	4.96
May 12	" normal; flowers expanded	17.86	77.68	4.46
June 6	" " flowers withered	14.75	78.35	6.90
July 1	" "	12.62	79.04	3.34
Aug. 2	" "	10.81	80.79	8.40
Sept. 2	" "	10.31	81.77	8.52
Oct. 1	" still green	11.19	80.61	8.20
" 31	" withered	8.87	83.13	8.00

PHOSPHORIC ACID IN THE ASH.

DATE.	In 100 Parts of Dried Leaves.	In 100 Parts of Ash.
April 15	1.400	31.67
June 6	0.770	11.16
Oct. 1	0.460	5.61
" 31	0.256	3.20

LEAVES OF THE MAPLE.

DATE.	REMARKS.	Nitrogenized Matter.	Carbonaceous Matter.	Ash.
May 1	Leaves small	40.94	53.06	6.00
" 7	" small, expanded	38.56	54.54	6.90
" 20	" larger	26.25	65.86	7.89
June 13	" normal	22.87	67.73	9.40
July 12	" "	20.19	68.17	11.64
Aug. 4	" "	19.59	68.13	12.28
Sept. 3	" "	20.62	65.88	13.50
Oct. 3	" fading	20.00	65.25	14.75
" 14	" fallen	14.80	69.00	16.20

PHOSPHORIC ACID OF THE ASH.

DATE.	In 10 Parts of Dried Leaves.	In 100 Parts of Ash.
May 1	2.797	49.62
June 13	0.957	10.18
Oct. 3	0.119	0.73

It will be at once observed that the absolute amount of nitrogenized substances differs widely as between the leaves of the two plants: there is at first far more in those of the maple than in those of the lilac, and this superiority is maintained during the whole period of vegetation.

Probably were we to examine from this point of view a large number of plants, we should find differences as great as these. Even between trees of the same species similar differences occur, according to their age and vigor, and more particularly according to the surroundings. Thus, on July 12, 1873, M. Corenwinder collected leaves of the common lilac in a garden situated in the open country near Saint-Quentin, and in them found:

Nitrogenized matters	18.56
Carbonaceous matters	72.90
Ash	8.54
	100.00

Comparing this analysis with that of the lilac-leaves which were gathered at the same time, but in a city-garden, we see that those which had plenty of air, growing in the country, remote from aggregations of human beings, are the richer in nitrogenized substances. They also grow thicker and larger, the activity of respiration devel-

oping their vitality, and promoting the growth of the organs which discharge that function. Hence it would appear that, for plants, as for animals, an abundant absorption of pure air, rich in oxygen, is the essential condition of a strong, vigorous constitution.

But these individual or specific differences have no importance as regards our problem. The point for us to consider is, not the *absolute* proportion of a given element, but rather the relative modifications which the initial proportion undergoes during the life of the leaf. Let us see what the tables have to say on this point:

1. During the growth of the leaves, the relative proportion of nitrogenized matter in their tissue grows rapidly less. It is at the maximum just when these organs are breaking out of the bud, and it goes on decreasing thenceforward till about the beginning of July, when the fruit of the lilac has been formed. From that time on, the quantity of nitrogenized matters varies but little, though it seems to gain a little in leaves approaching maturity. Finally, it is at the minimum when the process of vegetation is complete.

At the moment of their falling, we find in lilac-leaves only about one-third the amount of nitrogenized matters they contained at the outset. In maple-leaves the amount is relatively greater, but the difference is not very important.

2. If, now, we look at these analyses with respect to the amount of carbonaceous matters, we find that the latter rapidly increases from the moment when the leaves start from the bud, down to the time when they have attained their greatest size, i. e., when they have reached the adult age. As regards the lilac, this is the case when the flowers are ready to expand. The carbonaceous matters thenceforth gain less notably till September; but then we perceive a sensible decrease, especially as regards the maple. Finally, they attain the maximum at the time of falling from the tree, this rise being due to the disappearance of a notable amount of nitrogenized substances.

3. The ash, too, increases rapidly down to June, but then it grows less pronounced. There is relatively a greater amount of mineral matter in the faded leaves of the maple than in those of the lilac. The latter, at the close of their life, show a slight diminution, which is perhaps accidental, in mineral salts: being more tender than maple-leaves, they probably lose a little of their soluble salts under the action of rains.

We have only to compare the mature leaves of the maple with those of the lilac, in order to see that the former must contain more fixed salts than the latter: the fibres which traverse them are thicker, stronger, and more numerous, than in the leaves of the lilac, and hence they are richer in silica and salts of lime.

The ashes of these two trees differ very widely from one another. Even in the same species the quantity of the ash, like that of the nitrogenized matter, differs according to the surroundings, the age of

the plant, the humidity of the soil, and the heat to which it is exposed. It was proved by De Saussure that the quantity of ash is much less in nascent leaves than in those which have attained the term of their existence.

4. De Saussure also proved that in the ash of buds and nascent leaves there is more phosphoric acid than is found at any later stage. Since his time this fact has been confirmed by Garreau, of Lille, and by Corenwinder. The present series of experiments furnishes a new demonstration of this important phenomenon.

In the tables we have given the reader will observe that the proportion of phosphoric acid, which at the outset was considerable, especially in the maple-leaves, rapidly grows less, and when the process of vegetation is at an end it is very small indeed. Thus, when coming from the bud, they contain (in the dry state) about .028 phosphoric acid; but at last they contain only about .001. It was long ago proved by M. Corenwinder that the phosphorus contained in plants is an essentially variable quantity. It almost entirely disappears from the tissue of annual plants at the end of their growth, being condensed in the seeds, and ultimately serving to perpetuate the species. In perennial plants, the phosphorus does not go into the seeds merely —it is also diffused through the trunk and the branches; further, it hibernates in the buds, which contain the essential elements of the seed, and which perform the same functions as the latter in the evolution of leaves.

V.

Having now made the experiments tell their story, and described the comparative evolution of the various elements of the leaves during their annual life, let us next see whether these variations in chemical constitution may be coupled together under a theory which shall explain the modifications undergone by the gaseous exhalations of plants at the various stages of their life.

When we study closely the figures relating, for instance, to the maple, we find that, in the first stage of growth the nitrogenized matters are very considerable. Probably they have an organization of their own, and exist independently of the vegetal cells; at all events, they discharge functions which may be called *animal*—they *respire*, and in this early stage respiration is the dominant function. The carbonic acid resulting from this operation is at first only in part retained in the plant by the reducing action of the chlorophyll. The young plant, when exposed to the light and placed in atmospheric air, exhales an excess of carbonic acid.

In the second period, the *relative* proportion of nitrogenized matters grows less, while, on the other hand, the carbonaceous matters increase. The plant now exhales only a small amount of carbonic acid, the latter being almost entirely retained by the chlorophyll, which decomposes it, and fixes its carbon.

Later, the disengagement of carbonic acid ceases, that gas being instantly absorbed by the chlorophyll as soon as it is produced in respiration. The plant has now entered the adult stage. It freely absorbs the carbonic acid of the air, under the influence of the sun's rays, and gives off oxygen. The phenomenon of respiration is at this period completely masked, and cannot be shown to exist except by indirect processes, as we shall soon see.

On reading the column of figures headed "Carbonaceous Matters," we find that, in September, they grow rapidly less. Further, M. Corenwinder has discovered that, toward the beginning of October, the leaves exhaled a little carbonic acid in the daytime. Here the phenomenon is not of the same nature as at the beginning of vegetation: the yellow leaves are dying, and lose their carbon, like all decaying or dead organic matters exposed to the air. When vegetation is at an end, the proportion of carbonaceous matters seems to increase, owing to the rapid disappearance of nitrogenous matters.

From the facts established in the physiological and chemical experiments we have described we derive a very probable explanation of two phenomena, which at first view would seem to be mutually incompatible, viz., exhalation of oxygen and exhalation of carbonic acid. The latter of these has its seat in the nitrogenized matters, and constitutes the respiration of plants, which is henceforth to be esteemed the same as the respiration of animals. The other phenomenon has its seat in the chlorophyll. It has been wrongly held to be a respiratory act: it is, in fact, a true digestion of carbon.

VI.

From what has been said, we may unhesitatingly conclude that leaves in their earliest stage simultaneously perform two physiological functions: 1. They respire by means of their nitrogenous constituents; 2. They assimilate carbon by means of the carbonaceous matters organized in their tissues, i. e., the chlorophyll.

This act of respiration, as we have seen, becomes less apparent as the plant begins to assimilate carbon, but, in reality, it goes on uninterruptedly, being only masked by the increased activity of the other function. That this is the case may be proved experimentally.

In the first place, we know that plants cannot live in an atmosphere without oxygen. When they are placed in close vessels containing hydrogen and nitrogen, they live for a while, owing to the small quantity of atmospheric air in their cells; but yet, though outwardly they may give no sign of decay, on being taken out of the vessels they are found to be dead. The development of the buds ceases utterly in an oxygenless atmosphere. On March 29, 1872, M. Corenwinder placed a chestnut-bud in a test-tube containing atmospheric air, the mouth of the tube being immersed in a solution of caustic potash. The bud formed carbonic acid rapidly, inhaling the oxygen of

the air in the tube. The acid was absorbed, as soon as formed, by the alkaline solution, and the latter rose in the tube until there was no gas left except nitrogen.

The bud was kept in the nitrogen till May 2d; it then began to give signs of decay. During all this time it never gained in size, and retained its original form. The conclusion is, that *bud development cannot go on in an atmosphere deprived of oxygen.*

We know, further, from the observations of Th. de Saussure, that germination is impossible when the embryo, in process of growth, does not find, in the atmosphere in which it lives, the amount of oxygen needed for its life. Hence Corenwinder's experiment gives us a fresh instance of the resemblance between germination and the evolution of leaf-axes.

Th. de Saussure also examined several plants placed in an atmosphere of nitrogen. According to their behavior under these circumstances, he divides them into two categories, viz., those which vegetate in such an atmosphere only for a few days, and those which live and even flourish there for a certain length of time. Plants of the latter class are chiefly those which inhabit marshy situations, such as *Lythrum salicaria*, *Epilobium hirsutum*, *Polygonum amphibium*, etc. He has expressed the opinion that plants possessed of this latter property consume less oxygen, vegetating in atmospheric air without much light.

If, in M. Corenwinder's experiments, plants wither rapidly, the reason is, that in the morning he drew off the carbonic acid formed during the night by the agency of the oxygen contained in the cells. When this is not done, the leaves may decompose the acid in the daytime, give out oxygen, and so live for a long time, the oxygen being inhaled and exhaled over and over again.

Finally, if the leaves be kept in absolute darkness, the reducing action is null, and then the act of respiration, which, of necessity, is never completely suspended, alone appears, and the plant disengages only carbonic acid. This function, however, is curiously affected by temperature, so that, at 32° Fahr., leaves usually exhale but little carbonic acid.

These early observations would of themselves suffice to show the existence in plants, at every stage of growth, of a respiratory action, like that of animals, viz., an absorption of oxygen.

What in the books is called the diurnal respiration of plants, is in reality an assimilation of carbon; in other words, it is the act whereby the leaf-organs decompose the carbonic acid of the air, and give out its oxygen. This act depends essentially on the influence of light. It is at the maximum intensity when the plant is under the direct action of the sun's rays, and gradually diminishes in importance in proportion as the light grows feebler; for instance, when the sky is overcast with clouds, and when the weather is thick and rainy. This was demonstrated in a memoir by Corenwinder, published in 1858.

Still, with full-grown leaves in the open air, and with abundance of light, we but rarely find them exhaling even a very small amount of carbonic acid; though—as was shown by M. Corenwinder ten years ago—if we transfer them to a room lighted only by side-windows, and to which the direct rays of the sun do not penetrate, they generally, under these conditions, exhale carbonic acid in the daytime, the proportion varying according to the nature of the plants, the weakness of the diffused light, and the temperature. Of all the plants experimented on in this way by M. Corenwinder, the common nettle appeared to give out the largest amount of carbonic acid, when kept in a room.

These facts M. Corenwinder announced ten years ago, but he did not then venture an interpretation of them, as he does now.

M. Boussingault has shown that leaves placed in a bell-glass containing pure hydrogen mixed with a little carbonic acid, and kept in an ill-lighted room, give off traces of oxygen. This proves that even under the most unfavorable conditions the assimilation of carbon does not entirely cease: this act is completely suspended only in total darkness.

Now, as it is likewise certain that, under the same conditions as to light, leaves kept under a bell-glass *filled with air* give out carbonic acid, and inhale oxygen, it follows inevitably, from these two classes of observations, that the functions inherent in plants, respiration and assimilation of carbon, are simultaneous; *the latter function is, however, reduced to such a degree that it no longer completely masks the effect of the former;* in other words, the chlorophyll can no longer absorb all the carbonic acid produced by respiration.

Here, then, we have a fact analogous to that which we see in the earliest stage of vegetation, with this difference, that in the case of the bud the reducing action is insufficient, owing to the relative inferiority of its carbonaceous matters, while in the other case the insufficiency results from the reduction of their power.

These facts are undoubtedly very strong arguments for the theory of two simultaneous functions in leaves. M. Corenwinder still further confirms it with sundry observations, which are easily made.

Place perfectly green, full-grown maize-leaves under the bell-glass of the apparatus already described, and it will be seen that in the daytime they do not exhale the slightest trace of carbonic acid. If we could deprive these leaves of their green matter, which to all intents and purposes performs the assimilative function, we could doubtless discover the other function which this conceals, viz., respiration. Now, this very experiment Nature makes easy for us. As all are aware, there is a species of maize with striped leaves, which often bears white leaves without a trace of green. If we examine closely the striped leaves, we shall see that their white portions have absolutely no chlorophyll within. This is not the case with the leaves of a purple or of a black color; these, in addition to the coloring matter characteristic

of them, contain always more or less green matter, masked. They also possess the property, which the white leaves do not, of absorbing carbonic acid, and exhaling oxygen in a perceptible degree, when exposed to the sun. We lay stress on these phenomena, since it is for want of having understood them that very recent authors describe colored leaves as being usually deprived of the function of assimilation.

If we make the experiment already described with white leaves, we shall find that in the daytime they exhale a perceptible amount of carbonic acid.

Sennebier had observed that the yellow and red stripes of the *Amarantus tricolor* do not give off oxygen when exposed to the sun, but that the leaves of the *Amarantus ruber*, on the contrary, possess this property. So, too, leaves naturally green, which change color at the close of their life, entirely cease from absorbing carbonic acid and exhaling oxygen. Corenwinder has shown that faded leaves that are on the point of falling constantly give out carbonic acid. The fact seems to be universal. Here, however, it is not a phenomenon of vitality that appears, but an act of decrepitude, which goes on and increases after the leaf has fallen.

We observe the same phenomena in other plants, some of whose leaves contain no green matter whatever, especially in the striped maple, which is such an ornament of our gardens in summer. In August, 1868, M. Corenwinder gathered off one and the same maple some leaves that were perfectly white, and others that were perfectly green, and analyzed them to determine the amount of nitrogen they respectively contained, with the following results:

WHITE LEAVES.

Nitrogenized matters in 100 grammes, dried at 212° Fahr..... 17.06 gr.

GREEN LEAVES.

Nitrogenized matters in 100 grammes, dried at 212° Fahr..... 13.75 gr.

Thus we find a much larger amount of nitrogenous elements in the white leaves than in those which contain chlorophyll; on the other hand, the latter are richer in carbonaceous substances. These two observations clearly confirm M. Corenwinder's theory.

Finally, we may conclude, from all the analyses and experiments we have here detailed, that there exist in plants, at every stage of their life, two distinct functions having different centres of action. The one is *respiration*, which depends upon the nitrogenous organic bodies. The other is assimilation of carbon, which has its seat in special organisms, formed principally, if not exclusively, of ternary elements.

This theory gives a natural explanation of all observations upon the physiology of leaves. M. Corenwinder hopes soon to make an application of it, and will show what it is worth, by explaining, with its aid, the origin of carbon in plants.

FACIAL ANOMALIES.

By Dr. KARL MÜLLER.

I WAS once sitting in a cool underground saloon at Leipsic, while without people were ready to die from the heat, when a new guest entered and took a seat opposite to me. The sweat rolled in great drops down his face, and he was kept busy with his handkerchief, till at last he found relief in the exclamation, "Fearfully hot!" I watched him attentively as he called for a cool drink, for I expected every moment that he would fall from his chair in a fit of apoplexy. The man must have noticed that I was observing him, for he turned toward me suddenly, saying, "I am a curious sort of person, am I not?" "Why?" I asked. "Because I perspire only on the right side." And so it was; his right cheek and the right half of his forehead were as hot as fire, while the left side of his face bore not a trace of perspiration. I had never seen the like, and, in my astonishment, was about to enter into conversation with him regarding this physiological curiosity, when his neighbor on the left broke in with the remark, "Then we are the opposites and counterparts of each other, for I perspire only on the left side." This, too, was the fact. So the pair took seats opposite to each other, and shook hands like two men who had just found each his other half. "Well! this makes an end of natural history," exclaimed another guest, who hitherto had quietly gazed on this strange performance as though it were a play; and every one that had overheard what was said came to look at this novel wonder.

"This makes an end of natural history!" This expression excited me to laughter, and involuntarily I exclaimed: "No, sir, this is just the beginning of natural history; for Nature has many strange caprices even as regards her symmetry. I then mentioned the case of a man I had known in my boyhood, who, Janus-like, had two totally different faces—on one side laughing, on the other crying. Naturally I dreaded this strange double face, with its one side smooth, plump, and comely, like a girl's cheek, while the other side was all scarred by the small-pox. This side of the face denoted churlishness; and, while the other side wore a smile, this boded mischief. In this instance disease had been unsymmetrical.

Seated again in a different place, I mentioned to a friend, a physiologist, the wonderful anomaly I had seen. "Why," said he, "only look at the young Assessor von Th., yonder; he will show you an asymmetry such as you will not meet with every day." Sure enough, this man had a nose which was situated by no means in the middle of his face. I had seen this young man often before, but had never clearly made out what it was in his face that impressed me. Now I saw it at once: it was the man's nose; and since then I have come to see that

only a minority of mankind have their noses right in the middle of their faces; and most of us have our noses very much out of place without suspecting it.

But the eyes! Surely, those windows of the soul, can never be charged with asymmetry! I used to think Nature had too correct an æsthetic sense to do such a thing as that. But I know two persons, one of whom, a man, has one eye brown and one blue; the other of them, a woman, has one eye blue and one black—her hair being brown. In such a state of things, all we can say is, that the blending of the two parents is under some conditions not perfect. Strictly speaking, this too is the case where southron and northern, with black hair and blue eyes, or with light hair and black eyes, are still in antagonism, and where consequently the Darwinian force of inheritance is not yet fully established—in other words, where a new race is not yet formed. And, in the face of these facts, what are we to think of the eye as the "mirror of the soul?" Here one eye flashes and threatens, and the other is as mild as the German spring-time, the while only one heart beats and throbs in the bosom. Nay, the heart itself is not always in its own place; it sometimes occupies the right side of the chest. But it is of the eyes I was speaking, and not of the heart. I do not propose to discuss the whole question of the color of the eyes, down to albinism; I would simply observe that, as seen through them, the world wears a very different aspect for different individuals—a circumstance which, however, has nothing to do with asymmetry. Some eyes see only complementary colors, e. g., red instead of green; others see no color at all, every thing appearing to them like a copperplate engraving.

But color, too, has its caprices, as shown in the hair. I once asked an acquaintance why he did not allow his mustache to grow. His reply was, because on one side it was light brown, and on the other white; and he bade me look at his eyebrows, where I would find at least a partial confirmation of what he said. In fact, my friend had not stated the whole truth, for the dualism was faintly discernible even in the hair of his head. When a boy, I knew a whole family, the young members of which had each on the poll one or two locks of white hair. It was but yesterday I discovered, among my Christian neighbors, a descendant of Abraham, having black, curly hair, but blue eyes, and light eyebrows and mustache—the latter being as becoming to its handsome wearer as if his hair had been brown. Clearly a reversion from Western race-mixture to the Oriental type! I am confident that similar anomalies might often be noted if the attention were directed to them.

There are many other facial anomalies, which fail to attract attention, because we have grown accustomed to them. We should expect the convex cast of one side of the face to fit, line for line, into the concave cast of the other; but it is doubtful if there is to be anywhere

found one single head of this ideal perfection. Neither the contour of the cheeks, nor the lines of the countenance, are the same on both sides, and they are all the less so because every one unconsciously tends to perform many unilateral facial movements, which in time cause a divergence between the two sides of the face. Besides, the head, projecting as it does freely into air, is more dependent than we imagine on wind and weather. Suppose a person were to sit constantly at a window, turning one side to the cooler atmosphere out-of-doors, and the other toward a hot stove—the result would be a twofold growth of the facial muscles. One side of the face might become rounded, the other flat or concave; and, though such faces are not unfrequent, we do not notice the anomaly, simply because we are accustomed to it. In the Lapp we have a good illustration of this unequal development. Just as the trees of his native land are stunted, so too his features become monstrous, irregular, and one-sided: the frontal bones are forced, as though by spasm, down on the maxillaries, producing the most singular combinations and contortions of the features. A not uncommon form of asymmetry, in more favored lands, is the presence of a dimple on one cheek, while the other has no such indentation, or but a very faint one. In such cases the face has, as it were, a summer and a winter side, just like the apple, which is round and ruddy on its summer side, but on the shade-side flattened and wan.

We are too much inclined to regard these phenomena of asymmetry as merely accidental, whereas the fact is that they are the result of a universal law. Take, for instance, the case where the mustache is longer or thicker on one side of the lip than on the other; the law is everywhere the same: nothing is like any thing else, as Goethe has said. Throughout the entire organic world, and even down to the inorganic creation, down to the world of crystals, nothing that wears a specific form attains the full perfection of that form. I once requested a friend of mine, a mathematician, to reduce to a single formula the curves of an ivy-leaf. He spent weeks in measuring and calculating, but at last gave up the undertaking as an impossibility: no leaf was like another. Indeed, were Nature's forms ideally perfect, the result would be primness rather than beauty. Observe how powerfully the expression of the face is affected by the asymmetry between the upper and lower rows of teeth. The position of the eyes at equal distances on each side of the median line of the face—the nose—might seem to be indispensable for beauty, and yet how very rarely are the eyes placed with perfect symmetry! The wonder is, that these asymmetries of the face should be, after all, so slight as they are, considering how serious are the impediments placed in its way by the requirements of bodily growth. That the two halves of our body should grow so uniformly as they do, except in a very few instances, is the best evidence of the absolute unity of this form of organism, which is based on the vertebral column, and developed along with it.

The arrogant spirit of man revolts against the idea of its so-called bodily shell being a mere natural product, just like every other organized structure; but, for all that, the universal morphological law still remains. Art alone transcends all the requirements of natural production. Where art comes in play, the individual disappears; the contingent gives way before the eternal, the permanent. But this is a harmony that is never attained by Nature.—*Die Natur.*

THE CONFESSION OF A REFORMED SMOKER.

A RECORD OF OBSERVATIONS AND EXPERIMENTS CONCERNING THE PHYSIOLOGICAL ACTION OF TOBACCO.

By FRANCIS GERRY FAIRFIELD.

IN submitting the following observations as to the physiological effect of smoking, it is not my intention to discuss the tobacco question in an exhaustive manner, but, on the other hand, to limit my remarks to experiments tried and recorded in the course of the year ending July 10, 1874, and to the more general memoranda of the previous twelve years, during which the habit was formed, and, with the exception of brief paroxysms of abstinence, steadily developed. Many will no doubt dissent from the conclusions at which I arrived: to whom I have only to reply that my observations and experiments have not been, save in a cursory memorandum now and then, extended beyond my own person, and represent uniquely the manner in which I have been individually affected by habitual smoking. So far as I have any opinion to express, it consists of induction from actual experiments, and of inferences from actual symptoms; and, if I seem to leave many points undetermined, it must be set down to the fact that they are not within the scope of the particular method I have followed. That tobacco differently affects different temperaments there is no doubt. That different grades and qualities of tobacco differ materially in their physiological action, in manner and symptom, if not essentially, is demonstrated by experiment. In smoking, even, to say nothing of other forms of the tobacco-habit, it makes a material difference whether the same quality is used in conjunction with the pipe or consumed in the form of the cigar—a fact mainly due, no doubt, to the escape of the pyreiline, a base of extreme volatility, in cigar-smoking, and to its conservation to a greater extent in pipe-smoking. Yet, making all due allowances for differences of temperament, for the bias of transmitted habit, and for idiosyncrasies developed by special circumstances, I am constrained to the conclusion that, in the majority of instances, the habit of smoking is productive of nervous degeneracy.

My own case is possibly an extreme one, though not, I am inclined to think, to the extent of vitiating its application to the majority. My father used tobacco. My grandfather on my mother's side, a physician by profession, whose physical and mental traits I inherit to a considerable extent, was a moderate smoker; whether my paternal grandfather used the weed I have no means of ascertaining. I may add, however, that its use is pretty common among the collateral limbs radiating from the family trunk, and that there is hence no reason for regarding the phenomena in my case as the results of constitutional antagonism to the narcotic.

I have been a smoker, or had been up to July, 1874, for thirteen years, having commenced at the age of twenty-two. During the first three years I was somewhat irregular in my habits, sometimes smoking a pipe, sometimes consuming cigars at the rate of from three to five per day, and sometimes refraining altogether for from three days to a week.

I am of cerebro-muscular temperament; of slender *physique*, though broad-shouldered; with great physical endurance conjoined to peculiar sensitiveness of nervous organization, am yet not liable to the nervous excitability generally associated with sensitiveness. Opium and its preparations take their normal narcotic effect in very minute doses, inducing languor and drowsiness within a few minutes after administration. No tendency to talk precedes narcotism, nor is the slightest tendency to fantasy developed by the drug. Hasheesh acts in a manner analogous to morphia, bringing on stupor at the moderate dose, but engendering none of those deliciously intangible sensations which are so generally attributed to its action by Bayard Taylor and others who profess to have experimented with it.

Alcoholic stimulants act limitedly as excitants, but powerfully and rapidly as sedatives. I soon fall asleep under the action of whiskey and brandy. Wines, also, are generally sedative; but ale acts as a stimulant to the brain and nerve-centres with unerring certainty of effect, while its sedative action is long postponed and extremely unreliable. Have never used stimulants habitually, or even with ordinary frequency. Have taken morphine in quarter-grain doses, or the equivalent in laudanum, a dozen times, possibly, in the course of as many years. Am regular in my habits, temperate, and accustomed to protracted intellectual effort; inherit a narcotic tendency from my father, which exhibits itself in peculiar psychical phenomena whenever defective nutrition or protracted nervous tension is permitted.

One idiosyncrasy is worth noting at this stage of the narrative. Although I have smoked habitually for ten years, I have never been able to take tobacco in my mouth without violent nausea, or even to retain a cigar between my teeth; and have always been compelled to remove my cigar frequently from my lips and to carry it between my fingers, when not in actual use. In short, the slightest and most mo-

mentary contact of tobacco with the nerves of taste produces instant and uncontrollable nausea, though I am exceedingly fond of smoking, and have always been reckoned a connoisseur in flavors. I should add, however, that offensive sights, as of a person deformed or idiotic, and offensive odors, have the same effect, and instantaneously produce violent nausea.

The physiological effect of tobacco, when I first began to use it, was intense and disagreeable, producing contraction of the pupil of the eye, dizziness, labored breathing, and considerable tendency to spasms; and as these symptoms were more marked with the pipe than with the cigar, in which the pyrieline is mostly disengaged by the surrounding atmosphere, I conclude that they were due in the main not to the nicotine, but to the pyrieline and picoline bases, which are more immediately responsible for the first poisonous action of tobacco-juice when swallowed. Their action is more rapid when taken internally than when subcutaneously injected; and, though substantially identical with that of nicotine, is rather less distinctly narcotic, rather less immediately nervous, and rather more definite in its tendency to produce convulsions. As the nerves become habituated to the narcotic, a state of pleasant and exhilarated reverie, after smoking a few minutes, superseded the more obtrusive symptoms, and lasted sometimes half an hour or more, when languor supervened; and, as the habit became settled, it was accompanied by a mental aura, marked by general tendency to abstraction, and by a dreamy, metaphysical habit of thought. Vague generalizations took the place of real observation in the physical sciences to a greater extent than is compatible with progress in physics. I was intolerant of particulars, and impatient with nicety of discrimination, although I had previously been of extremely analytic habit, and noted in the academy and at college for subtilty as an algebraist. I had my logic of shadows and reveries, and was, withal, a little inclined to mysticism after the German pattern, and to vast theological speculations.

At the same time there was some gain in repose of nerve from the use of the weed, and some trifling gain in mental concentration, particularly as respected the study of Hegel, Schelling, Kant, and the German metaphysicians at large, which happened just then to be in my way. Hegel's *anima mundi* and I were on terms of familiar intimacy, and Schelling's fine discrimination between the different shades of shadows was accepted as really valuable in its contributions to philosophical literature. I mean no disrespect to Hegel and Kant, whose definition of life as self-aim has the merit of brevity, and will, perhaps, by-and-by, have to be incorporated into biology; only generalizing is by so many degrees easier than investigation that men come, I think, sooner or later—some sooner, some later—to have a kind of contempt for mere metaphysical speculation, however imposing its painted bubbles of imagined reality, and to long for a little truth

founded on fact, not on mysterious trains of ratiocination, having no basis except an introspective one.

On the other hand, there was some loss of sympathy with life. The actual was hazy and Rembrandtish. Day in and day out I speculated on Hegelian nothings—mere dodges in words—as if they had been underlying principles; and it was not until years after, when the passion for physics had possessed me, that it occurred to me that the *anima mundi* was but an ancient whim under a new name, and that the infinite potentiality which the Hegelists talk about was simply a symbol in nine syllables for something that in plain English (or German) is expressed in one—a gain in grandeur of phrase to be sure, but no real gain in other respects.

That these paragraphs fairly contrast the psychological exponents of the tobacco-habit with the normal condition of my mind, I have been able to satisfy myself by many experiments. By refraining from the use of tobacco for three or four weeks, on a few occasions longer than that, I have returned to the old dramatic sympathy with life; while, by taking up the habit again, I have leaped in a day from the one condition to the other. This experiment I have repeated many times within the past five years, always with the same transition from one series of psychological experiences to the other and very different series. I fancy Nero must have been a smoker, though there is no record of tobacco in those days; for a great deal that passes for firmness, and not a little that passes for cruelty, in this world, is but the apathy of narcotism in its maturer stages. Indeed, it is an open question whether the tobacco-habit was not largely instrumental in engendering the peculiar stoicism of the American Indian and in promoting its culture.

As the process of narcotizing is persisted in, languor attacks the will, there is sinking at the heart on waking up in the morning, the system craves stimulants with a mighty and unappeasable craving, and the motor centres respond but numbly to the motions of consciousness. The incapacity to recollect that marks the advanced stage is clearly the result of languid volition, engendered by torpor of the motor centres.

These symptoms indicate that the great nervo-vital centre, the medulla oblongata, which distributes its forces alike to body and brain, coördinated now as vital phenomena, now as psychical phenomena, is more or less involved, and that vital paralysis is liable to supervene at any juncture. But even at this stage the symptoms yield so rapidly to abstinence as to leave no doubt in my mind that the specific influence of the tobacco is transmitted directly to the great vital tract by means of the pneumogastric nerve. The depressed action of the heart, long before the cerebral centres are involved, points directly to this conclusion, and the augmented gastric and salivary secretions indicate the same avenue of action. The tendency to congestion of the lungs

that accompanies the tobacco-habit also sustains this hypothesis; and this may be produced in animals by introducing a very minute dose of decoction of tobacco into the system by way of the mouth, while subcutaneous injection is not equally rapid in producing this special result, nor, indeed, in producing death. Nor have I any doubt, from the few experiments I have tried, and the many I have witnessed, that, in opium-smoking, the peculiar symptoms are occasioned by a similar action of the vapor of the drug (on the medullary tract by way of the pneumogastric nerves). The olfactory nerves are, of course, more or less affected, and transmit the specific influence of either drug directly to the interior lobes of the brain; but experiment and observation alike tend to the conclusion that, though dizziness is somewhat accelerated by this action, it is trifling even in its cerebral effect, and that the great thoroughfare of activity is by way of the pneumogastric. The disturbances in locomotion arising from tobacco are thus secondary effects propagated, not by way of general nervous disturbance, but by direct appeal to the great coördinating centre, the cerebellum, through the near-lying and directly-connected vital tract. The vertiginous symptoms that accompany disturbances of the latter class must not be confounded with those that originate by way of the olfactory nerves, as the whirling sensation is far more marked and distinct in cerebellar disturbances, while the tendency to unconsciousness is somewhat less so.

I am, in these remarks, let it be understood, simply giving the results of my own observations on my own person during the last thirteen years; and my conclusion, from the masses of data thus accumulated, is, that the great sensory and motor tract of gray neurine, known as the cortex, is not at all involved in the primary stages of the narcotism induced by smoking, though the reverse is often clearly true in the instance of opium, with its surer and swifter cerebral effect. Others may be very differently affected by habitual smoking. I simply contribute my leaf to the record; and, although I am not satisfied that the tobacco-habit ever produces neurosis, I am satisfied that it is often the exciting cause of nervous disorder in cases where the neurotic tendency exists, and that in these cases it is productive sometimes of morbid moral phenomena, in a degree only less marked than the epileptic aura, and penetrating to the very roots of volition and ethical emotion. My opportunities for observation in hospitals and asylums have not been extensive enough to permit me to pronounce definitely on the point I am about to suggest; but it is my impression that the larvated type of epilepsy occurs more frequently than any other among persons addicted to tobacco, and that the habit is very generally influential in the larvation of nervous maladies. Statistics only can settle this issue, which must be left to the consideration of medical psychologists.

In order that the lay reader may clearly apprehend the various

bearings of the facts, and the intimate relation of the diverse symptoms to each other in tobacco-sickness, it is, perhaps, necessary to map out the pneumogastric nerve and indicate its function, which is not fairly deducible from its name. The origin of nearly every pair of cranial nerves has been traced into the vital bulb, the medulla oblongata, or continuation and expansion of the spinal cord as it passes into the cranium, to blossom into the complex structure of the brain. This tract enters the cranium in six bodies, united in a bulb, and continuing the six strands of the marrow, namely—the two pyramidal continuing the anterior white strands of the spinal stem, the two olivary the interior and partly lateral strands of gray neurine, and the two restiform (corpora restiforma) the posterior white strands. There are two ways of dissecting a brain, each of which has merits of its own for special purposes. The first and more general consists in examining the encephalic mass from above downward, by removing it in successive slices. For descriptive anatomy, and for pathological examination, this method is perhaps preferable. The second consists in examining and unraveling the structure from the spinal bulb upward, by tracing its fasciculi as they expand, radiate, and enlarge; and I am inclined to think that this method has its advantages in tracing the genesis of psychical phenomena. To this bulb all the complex activities of the cerebro-spinal axis finally refer themselves: it is properly the calyx from which spring the three ganglionic masses —the mesocephale, cerebellum, and cerebrum. The par vagum, generally known as the pneumogastric nerves, spring laterally from this bulb, and properly include three pairs of nerves, namely—the glosso-pharyngeal, which supply the base of the tongue with sensation, and connect and coördinate the motions of the organ with those of the pharynx and of the digestive function; the pneumogastric, which, with the preceding, have their origin in filaments springing from the groove between the olivary and restiform bodies; lastly, the spinal accessory, originating laterally from the medulla spinalis, but joining the main stem near its ganglion, and distributed to the lateral muscles of the neck. From the cervical tract of this nerve, which is triple in its origin, spring filaments or strands that join the sympathetic and lingual nerves, others that proceed directly to the pharynx, and still others known as its cardiac ramifications. The superior laryngeal nerve, distributed to the upper portion of the larynx, and the recurrent nerve, distributed to the muscles of the larynx, are both portions of the pneumogastric system. This pair of nerves passes through the jugular foramen just anterior to the vein of the same name, and separates into three parts. In the foramen it presents a ganglionic expansion, and below it a long gangliform swelling which communicates with the facial, spinal accessory, sympathetic, glosso-pharyngeal, and superior spinal nerves—all of which are here gathered into a kind of elongated plexiform bundle. At this point the nerve has the compact-

ness and grayish tint of the ganglion. The pneumogastric portion now descends, passing before the lingual nerve and the jugular vein for a little distance, then behind, inclosed in the sheath of the carotid artery and jugular, rather closer to the vein than to the artery, to which it gives off filaments. The importance of this system will be evident when it is stated that it is principally concerned in the coördination of the functions of deglutition, articulation, respiration, circulation, and digestion. The three great functions of animal life, nutrition, respiration, and circulation, are, in briefer terms, mainly coordinated by the par vagum in its cervical, thoracic, and abdominal tracts. With the former and its filaments, and to a considerable degree with the thoracic, the specific influence of the tobacco has, in smoking, a contact exceedingly direct and protracted; and, if the general reader will trouble himself to map out in his own imagination the course, ramifications, and connections, of the pneumogastric system, he will see clearly that the congeries of symptoms occasioned by the initial cigar follows out, step by step, the complex relations of this tract to the vital functions, and that the physical and psychological exponents of the habit in its established stages are, similarly, the natural results of narcotism of this system, and of the great vital centre from which it springs.

To these general facts of observation let me now append the details of a series of experiments:

I had been an inveterate smoker for eight years, when, in the summer of 1872, certain symptoms resembling those of writer's cramp attacked the right arm, and gradually, though to a less alarming extent, enveloped the left. Physicians pronounced it a genuine case of writer's cramp; but, owing to the persistent absence of certain symptoms, among them brittleness and want of color in the fingernails, I was slow to accept the conclusion. There was reason enough why excessive scribbling should bring on the affection; but I was, nevertheless, doubtful, though I so far complied with the prescription as to have recourse to the ordinary electrical appliances insisted upon by Dr. Poore, in his admirable essays on the subject, which embody, in brief form, the memoranda of an expert of some years' practice.

As I half anticipated, the application was without material benefit. Tonics and nervines proved equally inefficacious, and for a year, with short intervals of relief, affairs did but get worse and worse. Blue ink, elastic pen-holders, and broad-nibbed pens, were altogether incapable of ameliorating the affection or mending the scrawling, irregular handwriting that resulted from it; and so essential is it that the hand and mind should work together in a kind of rhythm, in order to form a good style, or to preserve it when formed, that any affection of the nerves of the arm that breaks up this rhythm is nearly as fatal to the poet, essayist, and novelist, as to the artist or the pianist; and I soon found my sentences as cramped and dissonant as my manuscript.

In October, 1873, I started for the country on a brief furlough, having served through the heat of the summer as a member of the staff of the *Evening Post*, and, not finding the tobacco to my liking, was forced to be exceedingly temperate for several weeks. Slowly, yet perceptibly, the affection of the arms wore off. The hand and forearm were less numb when I woke up in the morning, and my handwriting began to assume its former continuity. This I attributed at first to rest, fresh air, and freedom from worry—an error in the main, as will presently appear, though a very natural one under the circumstances.

I had been at home four or five weeks when I succeeded in supplying my commissary department with a sufficiency of the weed of the required quality, in the mean time smoking a little undoctored Connecticut leaf, when the craving became too strong to be comfortably resisted, but consuming, probably, less than two ounces a week. Upon resuming my usual quantum, and within twenty-four hours after the resumption, my arms were as troublesome as ever, and no rest in the least availed to soften the shooting pains or dissipate the numbness (penetrated as if with lances of neuralgia) that enveloped the arm from the wrist to the shoulder. I was thoroughly dispirited, and contemplated shifting my profession and applying for admission to the bar. I did not yet suspect the relation between the tobacco-habit and the malady under which I was suffering.

Remaining in the country, however, longer than I at first intended, my supply of the weed ran out; and I was again reduced to vulgar rations of Connecticut leaf, of which I consumed the smallest quantity possible. The consequence was an immediate reduction of the pain and numbness in my arms. In the course of this somewhat intermittent use of the narcotic, I observed also that a certain cloudiness of recollection, and a slight tendency to aphasia—the latter due, probably, to action on the lingual nerve—followed the resumption of the full dose after an interval of abstinence, the former interfering materially with the opulence of illustration necessary to a good style, the latter annoying me now and then with slips of the tongue in ordinary conversation.

At this stage of the investigation, with the barest suspicion in my mind that tobacco was responsible for most of the ills my flesh had fallen heir to, or rather my nerves, I returned to New York in the latter part of December, and initiated a series of experiments, with a view to test the physiological action of the various brands, and to verify or disarm the suspicion.

December 26th.—Procured a quantity of Cuban tobacco known as Honradez, an extremely fine brand, and put myself on a ration of half an ounce per day. Continued this regimen for twelve days, without perceptible alteration in the symptoms so far as my arms were concerned.

29*th.*—After three days of Honradez regimen, slight tendency to tremor and sleeplessness, with exceeding dryness of the membrane lining the nose.

January 1*st.*—Accelerated tendency to tremor and sleeplessness. Went to bed at eleven o'clock, but did not finally lose myself until after the clock struck one; then wandered off into dream-land instead of dropping to sleep in the normal way. Dreams of a queer, trance-like cast, with occasional starts. (I should interpolate here that I usually fall asleep very quickly after going to bed, and sleep very soundly.)

4*th.*—Augmented tendency to tremor and sleeplessness, with occasional *secousses* of the limbs. Arms still as benumbed as ever, but with an uncomfortable tendency to jerk. Went to bed at eleven o'clock, but lay awake till after the clock struck three; then fell into a fitful but trance-like slumber.

5*th.*—Came out of my drowse by slow degrees, and breakfasted about ten o'clock. Irritable and peevish. Tried to write after breakfast, but my hand was too shaky. Smoked a pipe of Honradez, which seemed to subdue the tremor.

7*th.*—Increased tremor and sleeplessness. Went to bed as usual at eleven, but could not sleep. Took an anodyne (bromide of potash) at half-past three o'clock, and slept soundly until eleven the next morning.

I now increased the ration of Honradez to three-fourths of an ounce per day, with an intensification of the symptoms so rapid and determinate as to leave no doubt of their origin. I was wild with nervousness, yet could not sleep soundly, and invariably woke up in the morning with a more or less pronounced pain in the region of the corpora striata (across the forehead) shooting downward and backward to the base of the brain; but the symptoms were still limited to the motor tract (the corpora striata and its connections), and there were no perturbations of the sensory.

Weighed 121 lbs. 3 oz. when I commenced the experiment, and 120 lbs. 2½ oz. when it was concluded. It should be unnecessary to add that a carefully-regulated dietetic regimen accompanied the experiments from beginning to end, securing at once fullness and variety of nutrition.

11*th.*—Refrained altogether from the use of tobacco. Fell asleep several times during the day. Went to bed at a quarter before eleven, and was asleep before the clock struck. Slept, with occasional whiffs of dream, until half-past eight in the morning. Continued to abstain for ten days, the nervous system gradually recovering its tone, and the hours of sleep slowly retracting until they fell to a trifle less than eight. An increased craving for food, and relish for it, followed the first day's abstinence, and on the morning of January 12th I ate

my broiled steak and drank my cup of coffee with a relish to which I had long been a stranger. The longing for tobacco did not recur strongly until the third day, when it was so importunate that, had I not been trying an experiment, it would have triumphed over all scruples.

Mentally, during the ten days, I was as one coming to himself after a long drowse—an Epimenides recovering from weeks of trance; and, after the third day, during which I suffered from a dull, continuous pain at the base of the brain, in the medullary rather than the cerebellar region, the numbness began to disappear from the arms, which continued to improve pending the progress of the experiment.

21*st.*—Weighing 122 lbs. 6 oz., put myself on an allowance of three Reina Victoria (Regalia) cigars per day, one after each meal, and continued the regimen for ten days, with the same general result that had followed the pipe and Honradez regimen, but somewhat less marked in its nervousness and tendency to tremor.

31*st.*—Weighed 120 lbs. 15 oz., and smoked my last Reina Victoria.

February 1*st.*—Commenced another ten days of abstention, with recovery from the symptoms, at the expiration of which my weight was 122 lbs. 13 oz.

11*th.*—Placed myself on an allowance of a quarter of an ounce perique per day. The first day I suffered from dizziness after smoking, and from slight nausea while in the act. These symptoms disappeared on the second day. The use of this tobacco (a strong Louisiana variety) was not attended with the marked tendency to tremor and sleeplessness incident to Honradez, but with a marked narcotism of the motor tract, and a marked vital depression—the specific action, no doubt, of its excess of nicotine on the great nervo-vital centre, the medulla oblongata. On the fourth day a peculiar sinking at the heart kept me in bed half an hour later than usual in the morning, but a cup of strong coffee taken in bed dissipated the lassitude and restored the vital energy. The numbness in my arms grew more and more pronounced every day, until it required some minutes in the morning with the flesh-brush to readjust the circulation; and with this came a tendency of the legs to fall asleep, showing obstructed nervous circulation, to be followed, in the nature of things, by defective nutrition and ultimate paralysis. During the last two days of the experiment the vital depression became so oppressive that I resorted to brandy in doses of a tablespoonful three times a day. Lost 1 lb. 11½ oz. during the experiment.

Discarding the perique, with its excess of the nicotine, I now limited myself to three pipes of Honradez per day, with a resultant consumption of two ounces a week. This regimen I maintained until the first of April, when I put myself on a daily allowance of a quarter of an ounce of Virginia cavendish; but the vital depression was so rapid that I desisted from the experiment after four days of lassitude.

April 10*th.*—Left New York for the country a thorough valetudi-

narian; and, after abstaining for a few days, with a rapid recovery from the symptoms, commenced to smoke a specific allowance per day of Connecticut, four pipes in fact, which I continued until the first of June, with less vital depression than was produced by perique and cavendish, but with a distinct tendency in that direction, and with a more marked cloudiness of recollection than had followed either.

June 1st.—Withdrew the allowance of leaf and commenced to smoke irregularly an occasional cigar, scarcely one per day on the average, and to note the effect. The vital depression consequent upon a single cigar was often so great as to compel resort to quinine in two-grain doses. Finally, discarded the habit altogether, with sufficient benefit to the arms to assure me that the symptoms were contingent on the use of tobacco. The numbness had almost disappeared in three weeks of abstinence; I began to wake up refreshed in the morning, not in a vital swoon. My weight, July 10th, was 125 lbs. 3 oz., and I regarded myself as thoroughly convalescent of the habit, though still a Laocoon struggling with his serpents. A violent agitation of the mucous membrane lining the nose has, I should have stated in its proper place, attended every withdrawal of the narcotic, supervening on the second day. The throat has also been considerably affected at these crises, and all the phenomena of a violent cold have been brought on in a few hours; but whether these effects have been mainly due to the withdrawal of the heat evolved in smoking, or to recovery of the membrane from local narcotism, or whether in part to both, I cannot venture to say.

Omitting all details of analysis of different tobaccos as too familiar for repetition, my experiments have led me to conclude:

1. That nicotine is the special agent concerned in vital paralysis and in disturbances of muscular coördination, and that its action upon the medullary centres is propagated by way of the pneumogastric nerve; that the cerebellar centres (coördinating the muscles concerned in locomotion), and the corpora striata (or great motor ganglia of the cerebrum), are next affected; in other words, that the motor tracts follow the vital in yielding to the influence of the poison.

2. That the cortex of the brain is the last to be affected by nicotine, but is more specifically affected by the pyrieline, picoline, and collidine bases. Hence the difference in physiological action between Honradez, with its minimum of nicotine, and perique and cavendish, with their excess; also the analogous difference between Havana cigars and cigars manufactured from Connecticut leaf.

3. That smoking is often the exciting cause of the various neuroses, and always a fruitful source of local aneurism, by impairing the nervous circulation and laying the foundation for defective nutrition in various directions. Cessation from tobacco should be made a condition precedent to medical treatment in writer's cramp and nervous affections of that type (the paralytic).

I am not going to take any radical ground on the tobacco question in its general aspects. Every man must judge for himself, and experiment for himself, as to the physiological action of the weed. I have simply recorded my own experiences and experiments, and the conclusions to which they have impelled me. I will not even say that I shall never smoke another cigar, for temptations are often strong and sudden; but I will say that, in such an event, I should regard myself as the victim of a nervous infirmity, not as one merely indulging himself in a harmless and pleasant luxury—of a devil far easier to get out of the bottle, to apply a Moslem legend, than to get back and cork in again.

WOMAN SUFFRAGE AS AFFECTING THE FAMILY.[1]

By J. E. CAIRNES,

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I NOW turn to a side of the question on which Mr. Smith lays very great stress, and of which I am not in the least disposed to underrate the importance—the extension of the suffrage to married women. I do not yield to Mr. Smith, or to any one, in the firmness of my conviction that the family is at the bottom of our existing civilization, and I should, for my part, regard as dearly purchased any gain in material or political well-being which should introduce a jar or weakness into this pivot of our social system. But I believe that to open political life to women, far from being fraught with the disastrous consequences Mr. Smith anticipates, would, taking things in their entire scope, be productive of quite opposite effects. If I were asked to name the principal element of weakness in the family as things now stand, I should have no hesitation in pointing to the want of sufficient subjects of common interest between man and woman. It is owing to this that matrimonial engagements are entered into so rarely on the basis of any broad intellectual sympathy, such as might furnish some security for lasting affection, and so often at the bidding of impulses and fancies that do not outlive the honey-moon; and it is owing to the same cause that so very large a proportion of the lives of most husbands and wives are spent practically apart, with little or no knowledge on the part of either of the objects or aims that engross the greater portion of the other's thoughts and energies. That under such circumstances the marriage-tie is, on the whole, maintained as well as it is, seems rather matter for wonder; and to argue that the introduction of a new source of very profound common interest for husband and wife must of necessity weaken the bond, is, in my opinion, to

[1] Extracted from an article in *Macmillan's Magazine* for September, in reply to Goldwin Smith.

evince a singular inability to appreciate the real dangers now besetting the institution. It is true, no doubt, that every new subject of common interest for husband and wife must, from the nature of the case, constitute also a new possible occasion for disagreement; but, if this is to be accounted a good reason for excluding women from politics, they might with equal justice be excluded from literature, from the fine arts, from every thing in which men also take an interest—above all, from religion. The value of these several pursuits as bonds and cements of married life is just in proportion to the degree of common interest which husbands and wives take in them, and just in the same proportion also is the possible danger that they may become the grounds of dissension. Mr. Smith is greatly scandalized at the prospect of a man and his wife taking opposite sides in politics. I cannot see that it would be at all more scandalous than that a man and his wife should take opposite sides in religion—going, for example, every Sunday to different places of worship, where each hears the creed of the other denounced as soul-destroying and damnable. It will serve to throw light upon the present problem if we consider for a moment how it happens that this latter spectacle is on the whole so rarely presented, and that, even where the event occurs, it is so frequently found consistent with tolerable harmony in married life. The explanation, I have no doubt, is of this kind: where difference of religion consists with matrimonial happiness, it will generally be found that one or both of the partners do not take a very deep interest in the creeds they profess; while, on the other hand, where people do feel strongly on religion, they generally take care, in forming matrimonial alliances, to consort with those who, on fundamental points, are of the same opinion with themselves. Now, it seems to me that this may serve to illustrate for us what will be the practical working of politics in respect to married life when women begin to receive a political education, or at least to learn as much about politics, and take as much or as little interest in them, as men do. A number only too large of men and women will probably continue for long enough to take but small interest in public affairs, and these will marry, as they do now, with little reference to each other's political opinions; but the danger of discord from politics under such circumstances would be infinitesimal. The only cases in which this danger would become serious would be when both husband and wife were strong politicians. Here, no doubt, there would be danger; though no greater, I think, than when two persons of strong but opposite religious convictions enter into marriage. Mr. Smith seems to think that, because "religion is an affair of the other world," it is less likely than politics to be an occasion of strife. This is probable enough when people do not believe in another world; but when they do, and believe also that the fate of people there will depend on what they believe in this, I cannot see the wisdom of his remark. Some of the worst and cruelest wars that have

ever been waged have been religious wars; and so notoriously is religion an engenderer of strife, that it is now scarcely good manners to moot a religious question in private society, where politics are quite freely and amicably discussed. If persons of genuine but different religious opinions can contrive to get on together in married life, they would certainly not be likely to be severed by political differences, however strongly their opinions might be held. But, however this may be, my argument is that, in practice, such cases would very rarely occur. When politics became a subject of interest alike for men and women, it would very soon become a principal consideration in determining matrimonial alliances. Even now this is the case to some extent, and it will no doubt become more and more so as the political education of women advances. Mr. Smith's question, therefore, "Would the harmony of most households bear the strain?" may be answered by saying that in very few households would there be any strain to bear; while in most—at least in those in which politics were intelligently cultivated—home-life, no longer the vapid thing it is so often now, would acquire a new element of interest, and the family would be held together by powerful sympathies that now lie undeveloped.

Mr. Smith seems to think that, if women are only excluded from the suffrage, the harmony of married life can never be endangered by politics; but this is to attribute to the mere right of voting a degree of efficacy which I, for one, am not disposed to allow to it. If women only come to take an interest in politics—it matters not whether they have the suffrage or not—all the danger that can arise from the suffrage to married life will be already incurred. It is not the giving of a vote every four or five years that constitutes the danger, if danger there be; but the habitual mental attitude of husband and wife toward each other. Those, therefore, who share Mr. Smith's apprehensions on the present subject, ought clearly to take their stand against the suffrage movement very much higher up. They ought to oppose every extension of female education which may reasonably be expected to lead women to take an interest in politics. The intelligent study of history should, in the first place, be rigidly proscribed. Political economy would be excluded as a matter of course; and, along with it, that large and increasing class of studies embraced under the name "social." Every one of these, intelligently cultivated, leads inevitably, where faculty is not wanting, to an interest in contemporary politics; and if women are to be shut out from this field of ideas, lest perchance they should adopt opinions which should not be those of their future husbands, their education ought at once to be truncated by this large segment. Mr. Smith, indeed, suggests that women who are capable of discussing political questions "will find a sphere in the press." Does he then suppose that there would be less danger to the harmony of married life from women writing in the

press—writing leaders, perhaps, for strong party papers—than from tendering a vote at the polls every four or five years? Besides, the suggestion falls utterly short of the requirements of the case. The number of women who are capable, or who desire, to find a sphere in the press are never likely to be more than a handful: the number who desire a liberal education, in the best and broadest sense of that word, and who are or may become quite fitted to form sound opinions on political questions, are already to be numbered by thousands, perhaps I might say by tens of thousands: what their numbers will become in another generation, I will not pretend to conjecture. Mr. Smith's suggestion, therefore, though graciously meant, is hardly to the purpose. Plainly, nothing short of lopping off from the education of women some of the most important branches of human knowledge will meet the difficulty.

JOSEPH PRIESTLEY.[1]

By T. H. HUXLEY, LL. D., F. R. S.

IF the man to perpetuate whose memory we have this day raised a statue had been asked on what part of his busy life's work he set the highest value, he would undoubtedly have pointed to his voluminous contributions to theology. In season and out of season, he was the steadfast champion of that hypothesis respecting the Divine nature which is termed Unitarianism by its friends and Socinianism by its foes. Regardless of odds, he was ready to do battle with all comers in that cause; and, if no adversaries entered the lists, he would sally forth to seek them.

To this, his highest ideal of duty, Joseph Priestley sacrificed the vulgar prizes of life, which, assuredly, were within easy reach of a man of his singular energy and varied abilities. For this object he put aside, as of secondary importance, those scientific investigations which he loved so well, and in which he showed himself so competent to enlarge the boundaries of natural knowledge and to win fame. In this course, he not only cheerfully suffered obloquy from the bigoted and the unthinking, and came within sight of martyrdom, but bore with that which is much harder to be borne than all these—the unfeigned astonishment and hardly disguised contempt of a brilliant society, composed of men whose sympathy and esteem must have been most dear to him, and to whom it was simply incomprehensible that a philosopher should seriously occupy himself with any form of Christianity.

It appears to me that the man, who, setting before himself such an

[1] An Address delivered on the occasion of the presentation of a statue of Priestley to the town of Birmingham, August 1, 1874. With some additions.

ideal of life, acted up to it consistently, is worthy of the deepest respect, whatever opinion may be entertained as to the real value of the tenets which he so zealously propagated and defended.

But I am sure that I speak not only for myself, but for all this assemblage, when I say that our purpose to-day is to do honor, not to Priestley, the Unitarian divine, but to Priestley, the fearless defender of rational freedom in thought and in action; to Priestley, the philosophic thinker; to that Priestley who held a foremost place among "the swift runners who hand over the lamp of life,"[1] and transmit from one generation to another the fire kindled, in the childhood of the world, at the Promethean altar of Science.

The main incidents of Priestley's life are so well known that I need dwell upon them at no great length.

Born in 1733, at Fieldhead, near Leeds, and brought up among Calvinists of the straitest orthodoxy, the boy's striking natural ability led to his being devoted to the profession of a minister of religion; and, in 1752, he was sent to the Dissenting academy at Daventry—an institution which authority left undisturbed, though its existence contravened the law. The teachers under whose instruction and influence the young man came, at Daventry, carried out to the letter the injunction to "try all things; hold fast that which is good," and encouraged the discussion of every imaginable proposition with complete freedom, the leading professors taking opposite sides; a discipline which, admirable as it may be from a purely scientific point of view, would seem to be calculated to make acute rather than sound divines. Priestley tells us, in his "Autobiography," that he generally found himself on the unorthodox side: and as he grew older, and his faculties attained their maturity, this native tendency toward heterodoxy grew with his growth and strengthened with his strength. He passed from Calvinism to Arianism; and finally, in middle life, landed in that very broad form of Unitarianism by which his craving after a credible and consistent theory of things was satisfied.

On leaving Daventry, Priestley became minister of a congregation, first at Needham Market and secondly at Nantwich; but whether on account of his heterodox opinions, or of the stuttering which impeded his expression of them in the pulpit, little success attended his efforts in this capacity. In 1761 a career much more suited to his abilities became open to him. He was appointed "tutor in the languages" in the Dissenting academy at Warrington, in which capacity, besides giving three courses of lectures, he taught Latin, Greek, French, and Italian, and read lectures on the Theory of Language and Universal Grammar, on Oratory, Philosophical Criticism, and the Civil Law. And it is interesting to observe that, as a teacher, he encouraged and cherished, in those whom he instructed, the freedom which he had

[1] "Quasi cursores vitaï, lampada tradunt."—LUCRETIUS, "*De Rerum Nat.*," ii., 78.

enjoyed, in his own student days, at Daventry. One of his pupils tells us that—

"At the conclusion of his lecture, he always encouraged his students to express their sentiments relative to the subject of it, and to urge any objections to what he had delivered, without reserve. It pleased him when any one commenced such a conversation. In order to excite the freest discussion, he occasionally invited the students to drink tea with him, in order to canvass the subjects of his lectures. I do not recollect that he ever showed the least displeasure at the strongest objections that were made to what he delivered, but I distinctly remember the smile of approbation with which he usually received them: nor did he fail to point out, in a very encouraging manner, the ingenuity or force of any remarks that were made, when they merited these characters. His object, as well as Dr. Aikin's, was, to engage the students to examine and decide for themselves, uninfluenced by the sentiments of any other persons." [1]

It would be difficult to give a better description of a model teacher than that conveyed in these words.

From his earliest days, Priestley had shown a strong bent toward the study of Nature; and his brother Timothy tells that the boy put spiders into bottles to see how long they would live in the same air—a curious anticipation of the investigations of his later years. At Nantwich, where he set up a school, Priestley informs us that he bought an air-pump, an electrical machine, and other instruments, in the use of which he instructed his scholars. But he does not seem to have devoted himself seriously to physical science until 1766, when he had the great good fortune to meet Benjamin Franklin, whose friendship he ever afterward enjoyed. Encouraged by Franklin, he wrote a "History of Electricity," which was published in 1767, and appears to have met with considerable success.

In the same year, Priestley left Warrington to become the minister of a congregation at Leeds; and here, happening to live next door to a public brewery, as he says—

"I at first amused myself with making experiments on the fixed air which I found ready made in the process of fermentation. When I removed from that house I was under the necessity of making fixed air for myself; and, one experiment leading to another, as I have distinctly and faithfully noted in my various publications on the subject, I by degrees contrived a convenient apparatus for the purpose, but of the cheapest kind.

"When I began these experiments I knew very little of *chemistry*, and had, in a manner, no idea on the subject before I attended a course of chemical lectures, delivered in the academy at Warrington, by Dr. Turner, of Liverpool. But I have often thought that, upon the whole, this circumstance was no disadvantage to me; as, in this situation, I was led to devise an apparatus and processes of my own, adapted to my peculiar views; whereas, if I had been previously accustomed to the usual chemical processes, I should not have so easily thought of any other, and, without new modes of operation, I should hardly have discovered any thing materially new." [2]

[1] "Life and Correspondence of Dr. Priestley," by J. T. Rutt, vol. i., p. 50.

[2] "Autobiography," §§ 100, 101.

The first outcome of Priestley's chemical work, published in 1772, was of a very practical character. He discovered the way of impregnating water with an excess of "fixed air," or carbonic acid, and thereby producing what we now know as "soda-water"—a service to naturally, and still more to artificially, thirsty souls, which those, whose parched throats and hot heads are cooled by morning draughts of that beverage, cannot too gratefully acknowledge. In the same year Priestley communicated the extensive series of observations which his industry and ingenuity had accumulated, in the course of four years, to the Royal Society, under the title of "Observations on Different Kinds of Air"—a memoir which was justly regarded of so much merit and importance, that the society at once conferred upon the author the highest distinction in their power, by awarding him the Copley Medal.

In 1771 a proposal was made to Priestley to accompany Captain Cook in his second voyage to the South Seas. He accepted it, and his congregation agreed to pay an assistant to supply his place during his absence. But the appointment lay in the hands of the Board of Longitude, of which certain clergymen were members; and whether these worthy ecclesiastics feared that Priestley's presence among the ship's company might expose his majesty's sloop Resolution to the fate which aforetime befell a certain ship that went from Joppa to Tarshish, or whether they were alarmed lest a Socinian should undermine that piety which, in the days of Commodore Trunnion, so strikingly characterized sailors, does not appear; but, at any rate, they objected to Priestley, "on account of his religious principles," and appointed the two Forsters, whose "religious principles," if they had been known to these well-meaning but not far-sighted persons, would probably have surprised them.

In 1772 another proposal was made to Priestley. Lord Shelburne, desiring a "literary companion," had been brought into communication with Priestley by the good offices of a friend of both—Dr. Price—and offered him the nominal post of librarian, with a good house and appointments, and an annuity in case of the termination of the engagement. Priestley accepted the offer, and remained with Lord Shelburne for seven years, sometimes residing at Calne, sometimes traveling abroad with the earl.

Why the connection terminated has never been exactly known, but it is certain that Lord Shelburne behaved with the utmost consideration and kindness toward Priestley; that he fulfilled his engagements to the letter; and that, at a later period, he expressed a desire that he should return to his old footing in his house. Probably enough the politician, aspiring to the highest offices in the state, may have found the position of the protector of a man, who was being denounced all over the country as an infidel and an atheist, somewhat embarrassing. In fact, a passage in Priestley's "Autobiography," on

the occasion of the publication of his "Disquisitions relating to Matter and Spirit," which took place in 1777, indicates pretty clearly the state of the case:

"(126.) It being probable that this publication would be unpopular, and might be the means of bringing odium on my patron, several attempts were made by his friends, though none by himself, to dissuade me from persisting in it. But being, as I thought, engaged in the cause of important truth, I proceeded without regard to any consequences, assuring them that this publication should not be injurious to his lordship."

It is not unreasonable to suppose that his lordship, as a keen, practical man of the world, did not derive much satisfaction from this assurance. The "evident marks of dissatisfaction," which Priestley says he first perceived in his patron in 1778, may well have arisen from the peer's not unnatural uneasiness as to what his domesticated but not tamed philosopher might write next, and what storm might thereby be brought down on his own head; and it speaks very highly for Lord Shelburne's delicacy that, in the midst of such perplexities, he made not the least attempt to interfere with Priestley's freedom of action. In 1780, however, he intimated to Dr. Price that he should be glad to establish Priestley on his Irish estates; the suggestion was interpreted as Lord Shelburne probably intended it should be, and Priestley left him, the annuity of £150 a year, which had been promised in view of such a contingency, being punctually paid.

After leaving Calne, Priestley spent some little time in London, and then, having settled in Birmingham, at the desire of his brother-in-law, he was soon invited to become the minister of a large congregation. This settlement Priestley considered at the time to be "the happiest event of his life." And well he might think so, for it gave him competence and leisure; placed him within reach of the best makers of apparatus of the day; made him a member of that remarkable "Lunar Society" at whose meetings he could exchange thoughts with such men as Watt, Wedgewood, Darwin, and Boulton; and threw open to him the pleasant house of the Galtons of Barr, where these men, and others of less note, formed a society of exceptional charm and intelligence.[1]

[1] *See* "The life of Mary Anne Schimmelpenninck." Mrs. Schimmelpenninck (*née* Galton) remembered Priestley very well, and her description of him is worth quotation: "A man of admirable simplicity, gentleness, and kindness of heart, united with great acuteness of intellect. I can never forget the impression produced on me by the serene expression of his countenance. He, indeed, seemed present with God by recollection, and with man by cheerfulness. I remember that, in the assembly of these distinguished men, among whom Mr. Boulton, by his noble manner, his fine countenance (which much resembled that of Louis XIV.), and princely munificence, stood preëminently as the great Mæcenas; even as a child I used to feel, when Dr. Priestley entered after him, that the glory of the one was terrestrial, that of the other, celestial; and utterly far as I am removed from a belief in the sufficiency of Dr. Priestley's theological creed, I cannot but here record this evidence of the eternal power of any portion of the truth held in its vitality."

But these halcyon days were ended by a bitter storm. The French Revolution broke out. An electric shock ran through the nations; whatever there was of corrupt and retrograde, and, at the same time, a great deal of what there was of best and noblest, in European society, shuddered at the outburst of long-pent-up social fires. Men's feelings were excited in a way that we in this generation can hardly comprehend. Party wrath and virulence were expressed in a manner unparalleled, and it is to be hoped impossible, in our times; and Priestley and his friends were held up to public scorn, even in Parliament, as fomenters of sedition. A "Church-and-King" cry was raised against the Liberal Dissenters; and in Birmingham it was intensified and specially directed toward Priestley by a local controversy, in which he had engaged with his usual vigor. In 1791 the celebration of the second anniversary of the taking of the Bastile by a public dinner, with which Priestley had nothing whatever to do, gave the signal to the loyal and pious mob, who, unchecked, and indeed to some extent encouraged, by those who were responsible for order, had the town at their mercy for three days. The chapels and houses of the leading Dissenters were wrecked, and Priestley and his family had to fly for their lives, leaving library, apparatus, papers, and all their possessions, a prey to the flames.

Priestley never returned to Birmingham. He bore the outrages and losses inflicted upon him with extreme patience and sweetness,[1] and betook himself to London. But even his scientific colleagues gave him a cold shoulder; and, though he was elected minister of a congregation at Hackney, he felt his position to be insecure, and finally determined on emigrating to the United States. He landed in America in 1794; lived quietly with his sons at Northumberland, in Pennsylvania, where his posterity still flourish; and, clear-headed and busy to the last, died February 6, 1804.

Such were the conditions under which Joseph Priestley did the work which lay before him, and then, as the Norse Sagas say, went out of the story. The work itself was of the most varied kind. No human interest was without its attraction for Priestley, and few men have ever had so many irons in the fire at once; but, though he may have burned his fingers a little, very few who have tried that operation have burned their fingers so little. He made admirable discoveries in science; his philosophical treatises are still well worth reading; his political works are full of insight and replete with the spirit of freedom; and, while all these sparks flew off from his anvil, the controversial hammer rained a hail of blows on orthodox priest and

[1] Even Mrs. Priestley, who might be forgiven for regarding the destroyers of her household gods with some asperity, contents herself, in writing to Mrs. Barbauld, with the sarcasm that the Birmingham people "will scarcely find so many respectable characters a second time to make a bonfire of."

bishop. While thus engaged, the kindly, cheerful doctor felt no more wrath or uncharitableness toward his opponents than a smith does toward his iron. But if the iron could only speak!—and the priests and bishops took the point of view of the iron.

No doubt what Priestley's friends repeatedly urged upon him—that he would have escaped the heavier trials of his life and done more for the advancement of knowledge, if he had confined himself to his scientific pursuits and let his fellow-men go their way—was true. But it seems to have been Priestley's feeling that he was a man and a citizen before he was a philosopher, and that the duties of the two former positions are at least as imperative as those of the latter. Moreover, there are men (and I think Priestley was one of them) to whom the satisfaction of throwing down a triumphant fallacy is as great as that which attends the discovery of a new truth; who feel better satisfied with the government of the world, when they have been helping Providence by knocking an imposture on the head; and who care even more for freedom of thought than for mere advance of knowledge. These men are the Carnots who organize victory for truth, and they are, at least, as important as the generals who visibly fight their battles in the field.

Priestley's reputation as a man of science rests upon his numerous and important contributions to the chemistry of gaseous bodies; and to form a just estimate of the value of his work—of the extent to which it advanced the knowledge of fact and the development of sound theoretical views—we must reflect what chemistry was in the first half of the eighteenth century.

The vast science which now passes under that name had no existence. Air, water, and fire, were still counted among the elemental bodies; and though Van Helmont, a century before, had distinguished different kinds of air as *gas ventosum* and *gas sylvestre*, and Boyle and Hales had experimentally defined the physical properties of air, and discriminated some of the various kinds of aëriform bodies, no one suspected the existence of the numerous totally distinct gaseous elements which are now known, or dreamed that the air we breathe and the water we drink are compounds of gaseous elements.

But, in 1754, a young Scotch physician, Dr. Black, made the first clearing in this tangled backwood of knowledge. And it gives one a wonderful impression of the juvenility of scientific chemistry to think that Lord Brougham, whom so many of us recollect, attended Black's lectures when he was a student in Edinburgh. Black's researches gave the world the novel and startling conception of a gas that was a permanently elastic fluid like air, but that differed from common air in being much heavier, very poisonous, and in having the properties of an acid, capable of neutralizing the strongest alkalies; and it took the world some time to become accustomed to the notion.

A dozen years later, one of the most sagacious and accurate investigators who has adorned this or any other country, Henry Cavendish, published a memoir in the "Philosophical Transactions," in which he deals not only with the "fixed air" (now called carbonic acid or carbonic anhydride) of Black, but with "inflammable air," or what we now term hydrogen.

By the rigorous application of weight and measure to all his processes, Cavendish implied the belief subsequently formulated by Lavoisier, that, in chemical processes, matter is neither created nor destroyed, and indicated the path along which all future explorers must travel. Nor did he himself halt until this path led him, in 1784, to the brilliant and fundamental discovery that water is composed of two gases united in fixed and constant proportions.

It is a trying ordeal for any man to be compared with Black and Cavendish, and Priestley cannot be said to stand on their level. Nevertheless, his achievements are not only great in themselves, but truly wonderful, if we consider the disadvantages under which he labored. Without the careful scientific training of Black, without the leisure and appliances secured by the wealth of Cavendish, he scaled the walls of science as so many Englishmen have done before and since his day; and, trusting to mother-wit to supply the place of training, and to ingenuity to create apparatus out of washing-tubs, he discovered more new gases than all his predecessors put together had done. He laid the foundation of gas analysis; he discovered the complementary actions of animal and vegetable life upon the constituents of the atmosphere; and, finally, he crowned his work, this day one hundred years ago, by the discovery of that "pure dephlogisticated air" to which the French chemists subsequently gave the name of oxygen. Its importance, as the constituent of the atmosphere which disappears in the processes of respiration and combustion, and is restored by green plants growing in sunshine, was proved somewhat later. For these brilliant discoveries the Royal Society elected Priestley a Fellow and gave him their medal, while the Academies of Paris and St. Petersburg conferred their membership upon him. Edinburgh had made him an honorary doctor of laws at an early period of his career; but, I need hardly add that a man of Priestley's opinions received no recognition from the universities of his own country.

That Priestley's contributions to the knowledge of chemical fact were of the greatest importance, and that they richly deserve all the praise that has been awarded to them, is unquestionable; but it must, at the same time, be admitted that he had no comprehension of the deeper significance of his work; and, so far from contributing any thing to the theory of the facts which he discovered, or assisting in their rational explanation, his influence to the end of his life was warmly exerted in favor of error. From first to last, he was a stiff adherent of the phlogiston doctrine which was prevalent when his

studies commenced; and, by a curious irony of fate, the man, who by the discovery of what he called "dephlogisticated air" furnished the essential datum for the true theory of combustion, of respiration, and of the composition of water, to the end of his days fought against the inevitable corollaries from his own labors. His last scientific work, published in 1800, bears the title, "The Doctrine of Phlogiston established, and that of the Composition of Water refuted."

When Priestley commenced his studies, the current belief was, that atmospheric air, freed from accidental impurities, is a simple elementary substance, indestructible and unalterable, as water was supposed to be. When a combustible burned, or when an animal breathed in air, it was supposed that a substance, "phlogiston," the matter of heat and light, passed from the burning or breathing body into it, and destroyed its powers of supporting life and combustion. Thus, air contained in a vessel in which a lighted candle had gone out, or a living animal had breathed until it could breathe no longer, was called "phlogisticated." The same result was supposed to be brought about by the addition of what Priestley called "nitrous gas" to common air.

In the course of his researches, Priestley found that the quantity of common air which can thus become "phlogisticated" amounts to about one-fifth the volume of the whole quantity submitted to experiment. Hence it appeared that common air consists, to the extent of four-fifths of this volume, of air which is already "phlogisticated;" while the other fifth is free from phlogiston, or "dephlogisticated." On the other hand, Priestley found that air "phlogisticated" by combustion or respiration could be "dephlogisticated," or have the properties of pure common air restored to it, by the action of green plants in sunshine. The question, therefore, would naturally arise—as common air can be wholly phlogisticated by combustion, and converted into a substance which will no longer support combustion, is it possible to get air that shall be less phlogisticated than common air, and consequently, support combustion better than common air does?

Now, Priestley says that, in 1774, the possibility of obtaining air less phlogisticated than common air had not occurred to him.[1] But, in pursuing his experiments on the evolution of air from various bodies by means of heat, it happened that, on the 1st of August, 1774, he threw the heat of the sun, by means of a large burning-glass which he had recently obtained, upon a substance which was then called *mercurius calcinatus per se*, and which is commonly known as red precipitate:

"I presently found that, by means of this lens, air was expelled from it very readily. Having got about three or four times as much as the bulk of my materials, I admitted water to it, and found that it was not imbibed by it. But, what surprised me more than I can well express was, that a candle burned in this

[1] "Experiments and Observations on Different Kinds of Air," vol. ii., p. 31.

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air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air, exposed to iron or lime of sulphur; but, as I had got nothing like this remarkable appearance from any kind of air besides this particular modification of nitrous air, and I knew no nitrous acid was used in the preparation of *mercurius calcinatus*, I was utterly at a loss how to account for it.

"In this case also, though I did not give sufficient attention to the circumstance at that time, the flame of the candle, besides being larger, burned with more splendor and heat than in that species of nitrous air; and a piece of red-hot wood sparkled in it, exactly like paper dipped in a solution of nitre, and it consumed very fast—an experiment which I had never thought of trying with nitrous air."[1]

Priestley obtained the same sort of air from red lead, but, as he says himself, he remained in ignorance of the properties of this new kind of air for seven months, or until March, 1775,[2] when he found that the new air behaved with "nitrous gas" in the same way as the dephlogisticated part of common air does; but that, instead of being diminished to four-fifths, it almost completely vanished, and therefore showed itself to be "between five and six times as good as the best common air I have ever met with."[3] As this new air thus appeared to be completely free from phlogiston, Priestley called it "dephlogisticated air."

What was the nature of this air? Priestley found that the same kind of air was to be obtained by moistening with the spirit of nitre (which he terms nitrous acid) any kind of earth that is free from phlogiston, and applying heat; and consequently he says, "There remained no doubt on my mind but that the atmospherical air, or the thing that we breathe, consists of the nitrous acid and earth, with so much phlogiston as is necessary to its elasticity, and likewise so much more as is required to bring it from its state of perfect purity to the mean condition in which we find it."[4]

Priestley's view, in fact, is that atmospheric air is a kind of saltpetre, in which the potash is replaced by some unknown earth. And in speculating on the manner in which saltpetre is formed, he enunciates the hypothesis, "that nitre is formed by a real *decomposition of the air itself*, the *bases* that are presented to it having, in such circumstances, a nearer affinity with the spirit of nitre than that kind of earth with which it is united in the atmosphere."[5]

It would have been hard for the most ingenious person to have wandered farther from the truth than Priestley does in this hypothesis of his—and though Lavoisier undoubtedly treated Priestley very ill, and pretended to have discovered dephlogisticated air, or oxygen, as he called it, independently, we can almost forgive him when we re-

[1] "Experiments and Observations on Different Kinds of Air," vol. ii., pp. 34, 35.
[2] Ibid., p. 40. [3] Ibid., p. 48. [4] Ibid., p. 55.
[5] Ibid., p. 60. The italics are Priestley's own.

flect how different were the ideas which the great French chemist attached to the body which Priestley discovered.

They are like two navigators, of whom the first sees a new country, but takes clouds for mountains and mirage for lowlands; while the second determines its length and breath, and lays down on a chart its exact place, so that it, thenceforth, serves as a guide to his successors, and becomes a secure outpost whence new explorations may be pushed.

Nevertheless, as Priestley himself somewhere remarks, the first object of physical science is to ascertain facts, and the service which he rendered to chemistry, by the definite establishment of a large number of new and fundamentally important facts, is such as to entitle him to a very high place among the fathers of chemical science.

It is difficult to say whether Priestley's philosophical, political, or theological views were most responsible for the bitter hatred which was borne to him by a large body of his countrymen,[1] and which found its expression in the malignant insinuations in which Burke, to his everlasting shame, indulged in the House of Commons.

Without containing much that will be new to the readers of Hobbes, Spinoza, Collins, Hume, and Hartley, and, indeed, while making no pretensions to originality, Priestley's "Disquisitions relating to Matter and Spirit," and his "Doctrine of Philosophical Necessity illustrated," are among the most powerful, clear, and unflinching expositions of materialism and necessarianism which exist in the English language, and are still well worth reading.

Priestley denied the freedom of the will in the sense of its self-determination; he denied the existence of a soul distinct from the body; and, as a natural consequence, he denied the natural immortality of man.

In relation to these matters, English opinion, a century ago, was very much what it is now.

A man may be a necessarian without incurring graver reproach than that implied in being called a gloomy fanatic, necessarianism, though very shocking, having a note of Calvinistic orthodoxy: but, if a man is a materialist; or, if good authorities say he is and must be so, in spite of his assertion to the contrary; or, if he acknowledge himself unable to see good reasons for believing in the natural immortality

[1] "In all the newspapers and most of the periodical publications I was represented as an unbeliever in Revelation, and no better than an atheist."—*Autobiography*, Hutt, vol. i., p. 124. "On the walls of houses, etc., and especially where I usually went, were to be seen, in large characters, 'MADAN FOREVER; DAMN PRIESTLEY; NO PRESBYTERIANISM; DAMN THE PRESBYTERIANS,' etc., etc.; and, at one time, I was followed by a number of boys, who left their play, repeating what they had seen on the walls, and shouting out, '*Damn Priestley; damn him, damn him, forever, forever,' etc., etc.* This was no doubt a lesson which they had been taught by their parents, and what they, I fear, had learned from their superiors."—*Appeal to the Public on the Subject of the Riots at Birmingham.*

of man, respectable folks look upon him as an unsafe neighbor of a cash-box, as an actual or potential sensualist, the more virtuous in outward seeming, the more certainly loaded with secret "grave personal sins."

Nevertheless, it is as certain as any thing can be, that Joseph Priestley was no gloomy fanatic, but as cheerful and kindly a soul as ever breathed, the idol of children; a man who was hated only by those who did not know him, and who charmed away the bitterest prejudices in personal intercourse; a man who never lost a friend, and the best testimony to whose worth is the generous and tender warmth with which his many friends vied with one another in rendering him substantial help, in all the crises of his career.

The unspotted purity of Priestley's life, the strictness of his performance of every duty, his transparent sincerity, the unostentatious and deep-seated piety which breathes through all his correspondence, are in themselves a sufficient refutation of the hypothesis, invented by bigots to cover uncharitableness, that such opinions as his must arise from moral defects. And his statue will do as good service as the brazen image that was set upon a pole before the Israelites, if those who have been bitten by the fiery serpents of sectarian hatred, which still haunt this wilderness of a world, are made whole by looking upon the image of a heretic, who was yet a saint.

Though Priestley did not believe in the natural immortality of man, he held with an almost naïve realism, that man would be raised from the dead by a direct exertion of the power of God, and thenceforward be immortal. And it may be as well for those who may be shocked by this doctrine to know that views, substantially identical with Priestley's, have been advocated, since his time, by two prelates of the Anglican Church: by Dr. Whately, Archbishop of Dublin, in his well-known "Essays;"[1] and by Dr. Courtenay, Bishop of Kingston in Jamaica, the first edition of whose remarkable book, "On the Future States," dedicated to Archbishop Whately, was published in 1843, and the second in 1857. According to Bishop Courtenay—

> "The death of the body will cause a cessation of all the activity of the mind by way of natural consequence; to continue forever UNLESS the Creator should interfere."

And again:

> "The natural end of human existence is the 'first death,' the dreamless slumber of the grave, wherein man lies spellbound, soul and body, under the dominion of sin and death—that whatever modes of conscious existence, whatever future states of 'life' or of 'torment' beyond Hades are reserved for man, are results of our blessed Lord's victory over sin and death; that the resurrection of the dead must be preliminary to their entrance into either of the future states, and that the nature and even existence of these states, and even the mere

[1] First Series. "On Some of the Peculiarities of the Christian Religion." Essay I. Revelation of a Future State.

fact that there is a futurity of consciouness, can be known *only* through God's revelation of himself in the Person and the Gospel of his Son," p. 389.

And now hear Priestley:

"Man, according to this system" (of materialism), "is no more than we now see of him. His being commences at the time of his conception, or perhaps at an earlier period. The corporeal and mental faculties, in being in the same substance, grow, ripen, and decay together; and whenever the system is dissolved it continues in a state of dissolution till it shall please that Almighty Being who called it into existence to restore it to life again."—*Matter and Spirit*, p. 49.

And again:

"The doctrine of the Scripture is, that God made man of the dust of the ground, and, by simply animating this organized matter, made man that living percipient and intelligent being that he is. According to Revelation, *death* is a state of rest and insensibility, and our only though sure hope of a future life is founded on the doctrine of the resurrection of the whole man at some distant period; this assurance being sufficiently confirmed to us, both by the evident tokens of a Divine commission attending the persons who delivered the doctrine, and especially by the actual resurrection of Jesus Christ, which is more authentically attested than any other fact in history."—*Ibid.*, p. 247.

We all know that "a saint in crape is twice a saint in lawn;" but it is not yet admitted that the views which are consistent with such saintliness in lawn become diabolical when held by a mere Dissenter.[1]

I am not here either to defend or to attack Priestley's philosophical views, and I cannot say that I am personally disposed to attach much value to episcopal authority in philosophical questions; but it seems right to call attention to the fact that those of Priestley's opinions which have brought most odium upon him have been openly promulgated, without challenge, by persons occupying the highest positions in the state Church.

I must confess that what interests me most about Priestley's materialism is, the evidence that he saw dimly the seed of destruction which such materialism carries within its own bosom. In the course of his reading for his "History of Discoveries relating to Vision, Light, and Colors," he had come upon the speculations of Boscovich and Michell, and had been led to admit the sufficiently obvious truth that our knowledge of matter is a knowledge of its properties; and that of its substance—if it have a substance—we know nothing. And

[1] Not only is Priestley at one with Bishop Courtenay in this matter, but with Hartley and Bonnet, both of them stout champions of Christianity. Moreover, Archbishop Whately's essay is little better than an expansion of the first paragraph of Hume's famous essay on the Immortality of the Soul: "By the mere light of reason it seems difficult to prove the immortality of the soul; the arguments for it are commonly derived either from metaphysical topics, or moral, or physical. But it is in reality the Gospel, and the Gospel alone, that has brought *life and immortality to light*." It is impossible to imagine that a man of Whately's tastes and acquirements had not read Hume or Hartley, though he refers to neither.

this led to the further admission that, so far as we can know, there may be no difference between the substance of matter and the substance of spirit ("Disquisitions," p. 16). A step further would have shown Priestley that his materialism was, in substance, very little different from the idealism of his contemporary, the Bishop of Cloyne.

As Priestley's philosophy is mainly a clear statement of the views of the deeper thinkers of his day, so are his political conceptions based upon those of Locke. Locke's aphorism, that "the end of government is the good of mankind," is thus expanded by Priestley:

"It must necessarily be understood, therefore, whether it be expressed or not, that all people live in society for their mutual advantage; so that the good and happiness of the members, that is, of the majority of the members, of any state, is the great standard by which every thing relating to that state must finally be determined." [1]

The little sentence here interpolated, "that is, of the majority of the members of any state," appears to be that passage which suggested to Bentham, according to his own acknowledgment, the famous "greatest happiness" formula, which, by substituting "happiness" for "good," has converted a noble into an ignoble principle. But I do not call to mind that there is any utterance in Locke quite so outspoken as the following passage in the "Essay on the First Principles of Government." After laying down, as "a fundamental maxim in all governments," the proposition that "kings, senators, and nobles," are "the servants of the public," Priestley goes on to say:

"But in the largest states, if the abuses of the government should at any time be great and manifest; if the servants of the people, forgetting their masters and their masters' interest, should pursue a separate one of their own; if, instead of considering that they are made for the people, they should consider the people as made for them; if the oppressions and violation of right should be great, flagrant, and universally resented; if the tyrannical governors should have no friends but a few sycophants, who had long preyed upon the vitals of their fellow-citizens, and who might be expected to desert a government whenever their interests should be detached from it; if, in consequence of these circumstances, it should become manifest that the risk which would be run in attempting a revolution would be trifling, and the evils which might be apprehended from it were far less than those which were actually suffered, and which were daily increasing; in the name of God, I ask, what principles are those which ought to restrain an injured and insulted people from asserting their natural rights, and from changing or even punishing their governors—that is, their servants—who had abused their trust, or from altering the whole form of their government, if it appeared to be of a structure so liable to abuse?"

As a Dissenter, subject to the operation of the Corporation and Test Acts, and as a Unitarian, excluded from the benefit of the Toleration Act, it is not surprising to find that Priestley had very definite

[1] "Essay on the First Principles of Government," second edition, 1771, p. 13.

opinions about ecclesiastical establishments; the only wonder is that these opinions were so moderate as the following passages show them to have been:

"Ecclesiastical authority may have been necessary in the infant state of society, and, for the same reason, it may perhaps continue to be, in some degree, necessary as long as society is imperfect; and therefore may not be entirely abolished till civil governments have arrived at a much greater degree of perfection. If, therefore, I were asked whether I should approve of the immediate dissolution of all the ecclesiastical establishments in Europe, I should answer, No. . . . Let experiment be first made of *alterations*, or, which is the same thing, of *better establishments* than the present. Let them be reformed in many essential articles, and then not thrown aside entirely till it be found by experience that no good can be made of them."

Priestley goes on to suggest four such reforms of a capital nature:

"1. Let the Articles of Faith to be subscribed by candidates for the ministry be greatly reduced. In the formulary of the Church of England, might not thirty-eight out of the thirty-nine be very well spared? It is a reproach to any Christian establishment if every man cannot claim the benefit of it who can say that he believes in the religion of Jesus Christ as it is set forth in the New Testament. You say the terms are so general that even deists would quibble and insinuate themselves. I answer that all the articles which are subscribed at present by no means exclude deists who will prevaricate; and upon this scheme you would at least exclude fewer honest men." [1]

The second reform suggested is the equalization, in proportion to work done, of the stipends of the clergy; the third, the exclusion of the bishops from Parliament; and the fourth, complete toleration, so that every man may enjoy the rights of a citizen, and be qualified to serve his country, whether he belong to the Established Church or not.

Opinions such as those I have quoted, respecting the duties and the responsibilities of governors, are the commonplaces of modern Liberalism; and Priestley's views on ecclesiastical establishments would, I fear, meet with but a cool reception, as altogether too conservative, from a large proportion of the lineal descendants of the people who taught their children to cry "Damn Priestley," and, with that love for the practical application of science which is the source of the greatness of Birmingham, tried to set fire to the doctor's house with sparks from his own electrical machine, thereby giving the man, they called an incendiary and raiser of sedition against Church and king, an appropriately experimental illustration of the nature of arson and riot.

If I have succeeded in putting before you the main features of Priestley's work, its value will become apparent when we compare the condition of the English nation, as we knew it, with its present state.

The fact, that France has been for eighty-five years trying, without

[1] "Utility of Establishments," in "Essay on First Principles of Government," p. 198, 1771.

much success, to right herself after the great storm of the Revolution, is not unfrequently cited among us as an indication of some inherent incapacity for self-government among the French people. I think, however, that Englishmen who argue thus forget that, from the meeting of the Long Parliament in 1640, to the last Stuart rebellion in 1745, is a hundred and five years, and that, in the middle of the last century, we had but just freed ourselves from our Bourbons and all that they represented. The corruption of our state was as bad as that of the Second Empire. Bribery was the instrument of government, and peculation its reward. Four-fifths of the seats in the House of Commons were more or less openly dealt with as property. A minister had to consider the state of the vote market, and the sovereign secured a sufficiency of "king's friends" by payments allotted with retail, rather than royal, sagacity.

Barefaced and brutal immorality and intemperance pervaded the land, from the highest to the lowest classes of society. The Established Church was torpid, so far as it was not a scandal; but those who dissented from it came within the meshes of the Act of Uniformity, the Test Act, and the Corporation Act. By law, such a man as Priestley, being a Unitarian, could neither teach nor preach, and was liable to ruinous fines and long imprisonment.[1] In those days, the guns that were pointed by the Church against the Dissenters were shotted. The law was a cesspool of iniquity and cruelty. Adam Smith was a new prophet whom few regarded, and commerce was hampered by idiotic impediments, and ruined by still more absurd help, on the part of government.

Birmingham, though already the centre of a considerable industry, was a mere village as compared with its present extent. People who traveled went about armed, by reason of the abundance of highwaymen and the paucity and inefficiency of the police. Stage-coaches had not reached Birmingham, and it took three days to get to London. Even canals were a recent and much-opposed invention.

Newton had laid the foundation of a mechanical conception of the physical universe; Hartley, putting a modern face upon ancient materialism, had extended that mechanical conception to psychology; Linnæus and Haller were beginning to introduce method and order into the chaotic accumulation of biological facts. But those parts of physical science which deal with heat, electricity, and magnetism, and, above all, chemistry, in the modern sense, can hardly be said to have had an existence. No one knew that two of the old elemental bodies, air and water, are compounds, and that a third, fire, is not a substance but a motion. The great industries that have grown out of the applications of modern scientific discoveries had no existence, and the man, who should have foretold their coming into being in the days of his son, would have been regarded as a mad enthusiast.

[1] In 1732 Doddridge was cited for teaching without the bishop's leave, at Northampton.

In common with many other excellent persons, Priestley believed that man is capable of reaching, and will eventually attain, perfection. If the temperature of space presented no obstacle, I should be glad to entertain the same idea; but, judging from the past progress of our species, I am afraid that the globe will have cooled down so far before the advent of this natural millennium, that we shall be, at best, perfected Esquimaux. For all practical purposes, however, it is enough that man may visibly improve his condition in the course of a century or so. And, if the picture of the state of things in Priestley's time, which I have just drawn, have any pretense to accuracy, I think it must be admitted that there has been a considerable change for the better.

I need not advert to the well-worn topic of material advancement, in a place in which the very stones testify to that progress—in the town of Watt and of Boulton. I will only remark, in passing, that material advancement has its share in moral and intellectual progress. Becky Sharp's acute remark, that it is not difficult to be virtuous on ten thousand a year, has its application to nations; and it is futile to expect a hungry and squalid population to be any thing but violent and gross. But as regards other than material welfare, although perfection is not yet in sight—even from the mast-head—it is surely true that things are much better than they were.

Take the upper and middle classes as a whole, and it may be said that open immorality and gross intemperance have vanished. Four and six bottle men are as extinct as the dodo. Women do not gamble, and talk modeled upon Dean Swift's "Art of Polite Conversation" would be tolerated in no decent kitchen.

Members of the legislature are not to be bought, and constituents are awakening to the fact that votes must not be sold—even for such trifles as rabbits and tea and cake. Political power has passed into the hands of the masses of the people. Those whom Priestley calls their servants have recognized their position, and have requested the master to be so good as to go to school and fit himself for the administration of his property. No civil disability attaches to any one on theological grounds, and the highest offices of the state are open to papist, Jew, or secularist.

Whatever men's opinions as to the policy of Establishment, no one can hesitate to admit that the clergy of the Church are men of pure life and conversation, zealous in the discharge of their duties, and, at present, apparently, more bent on prosecuting one another than on meddling with Dissenters. Theology itself has broadened so much, that Anglican divines put forward doctrines more liberal than those of Priestley; and, in our state-supported churches, one listener may hear a sermon to which Bossuet might have given his approbation, while another may hear a discourse in which Socrates would find nothing new.

But, great as these changes may be, they sink into insignificance beside the progress of physical science, whether we consider the improvement of methods of investigation, or the increase in bulk of solid knowledge. Consider that the labors of Laplace, of Young, of Davy, and of Faraday; of Cuvier, of Lamarck, and of Robert Brown; of Von Baer, and of Schwann; of Smith and of Hutton, have all been carried on since Priestley discovered oxygen; and consider that they are now things of the past, concealed by the industry of those who have built upon them, as the first founders of a coral-reef are hidden beneath the life's work of their successors; consider that the methods of physical science are slowly spreading into all investigations, and that proofs, as valid as those required by her canons of investigation, are being demanded of all doctrines which ask for men's assent—and you will have a faint image of the astounding difference in this respect between the nineteenth century and the eighteenth.

If we ask what is the deeper meaning of all these vast changes, I think there can be but one reply. They mean that Reason has asserted and exercised her primacy over all provinces of human activity: that ecclesiastical authority has been relegated to its proper place; that the good of the governed has been finally recognized as the end of government, and the complete responsibility of governors to the people as its means; and that the dependence of natural phenomena in general, on the laws of action of what we call matter, has become an axiom.

But it was to bring these things about, and to enforce the recognition of these truths, that Joseph Priestley labored. If the nineteenth century is other and better than the eighteenth, it is to him and to such men as he that we owe the change. If the twentieth century is to be better than the nineteenth, it will be because there are among us men who walk in Priestley's footsteps.

Such men are not those whom their own generation delights to honor; such men, in fact, rarely trouble themselves about honor, but ask, in another spirit than Falstaff's, "What is honor? Who hath it? He that died o' Wednesday." But whether Priestley's lot be theirs, and a future generation, in justice and in gratitude, set up their statues; or whether their names and fame are blotted out from remembrance, their work will live as long as time endures. To all eternity, the sum of truth and right will have been increased by their means; to all eternity, falsehood and injustice will be the weaker because they have lived.—*From advance sheets of Macmillan's Magazine.*

SKETCH OF PROFESSOR HAECKEL.

ERNST HEINRICH HAECKEL, Professor of Natural History in the University of Jena, and one of the most eminent of German biologists, was born at Potsdam, in Prussia, on the 16th of February, 1834, and is consequently now but forty years of age. In his childhood he was very fond of botany. He studied medicine and the natural sciences at Berlin and Würzburg, and graduated as doctor of medicine in Berlin in 1857. In Würzburg he studied anatomy and histology under Kölliker and Leydig, and in Berlin under Johannes Müller. He became the assistant of the eminent pathologist Virchow, and commenced medical practice in Berlin in 1858. He had made scientific excursions to the Mediterranean in 1854 and 1856 with Kölliker and Müller; and in 1859–'60 a fifteen months' residence in Italy, which he employed in zoological researches, became the turning-point in his career, and he withdrew from the practice of medicine, and became a professed zoologist. He went to Jena in 1861, and was made professor extraordinary in the university in 1862. In 1865 the university created a regular chair of zoology specially for him, and he began the formation there of a valuable museum. From that time his lectures, together with those of Gegenbaur on comparative anatomy, have given great reputation to the Jena school. Prof. Haeckel is said to have declined very advantageous appointments to other universities mainly because he would not be separated from his friend Gegenbaur. Prof. Haeckel early accepted the views of Mr. Darwin, and has become their leading expositor in Germany. He has, besides, greatly extended and strengthened the theory of organic development by his own researches. His biographer in the AMERICAN CYCLOPÆDIA states that in 1863 "Darwinism" was generally looked upon with great disfavor in German scientific circles; and when, on September 19th of that year, Prof. Haeckel appeared before the convention of German physicians and naturalists held in Stettin, as the enthusiastic advocate of development doctrines, he stood almost alone, and thenceforth he determined to devote his life to their extension, establishment, and promulgation.

In 1866 he completed a work on the general morphology of organisms, in two volumes, which ranks as one of the landmarks of the science. In that work he propounded, as a fundamental biological law, "that the individual development of every organism, or the series of forms through which it passes from germ to complete form, repeats approximately the development of its race, or the series of forms through which its ancestors have passed. Moreover, all organic beings, hitherto, had been classified into the two kingdoms, animal and vegetable; but a number of creatures were found to present in exter-

nal form, in internal structure, and in all vital phenomena, so remarkable a mixture or combination of distinguishing animal and vegetable characteristics, that it was impossible, except arbitrarily, to assign them to either realm: he assigned these doubtful beings to a kingdom by themselves, below and yet between the two other organic kingdoms, and this he called *protistic*. Again and again in existing forms he traced development from preëxisting ones. Many biologists, among them Prof. Huxley, have pronounced this the most important work of the kind ever published."

In the winter of 1867–'68 he delivered a series of popular lectures, on the evolution doctrine in general, which were afterward amplified and published under the title of "The Natural History of Creation." Many editions of it have been called for, and it has been translated into several languages. Darwin says of it, in the introduction to the "Descent of Man:" "If this work had appeared before my essay had been written, I should probably never have completed it. Almost all the conclusions at which I have arrived, I find confirmed by this naturalist, whose knowledge on many points is much fuller than mine." This work will soon appear in English.

Prof. Haeckel's most important original contribution to the doctrine of evolution has been made by the study of the sponges. Considering that Darwin's mode of investigation was only synthetical, that is, "to prove the truth of the transmutation theory by arguments from philosophy and biology, from comparative anatomy and paleontology, by considerations of the mutual affinities of organic beings, of their embryological relations, their geographical distribution, geological succession, etc." Prof. Haeckel aimed to establish the theory by direct analytical proof. For this purpose "he has selected the group of calcareous sponges, and has shown by thousands of examinations the gradual transitions from the most simple to the most perfect sponge form." Prof. Haeckel's last considerable work is "The History of the Evolution of Man," just ready for issue in Germany, and a very large edition of which has been subscribed for. A translation of this work also will soon appear in English.

We are indebted for the leading facts of this sketch to the excellent notice of Haeckel in Volume VIII. of the AMERICAN CYCLOPÆDIA, where the reader will find a much fuller statement of his numerous contributions to biological science.

EDITOR'S TABLE.

MATTER AND LIFE.

THE narrow limits of Prof. Tyndall's address, the greatness of the questions it raised, and the diversity of views to which it has given rise, seem to have led to much erroneous interpretation of the document. Many newspapers have charged that the speech is an unprecedented and unwarranted aggression upon ground to which science has no rightful claim, and even the *Scientific American* describes the position taken by Prof. Tyndall as a "sudden invasion of the neutral territory lying between scientific and religious thought." The passage that has been most constantly quoted and relied upon, to show that Prof. Tyndall has quit his own field and intruded into that which belongs to religion, is where he speaks of "prolonging his vision across the boundary of the experimental evidence." But it is easy to show that this passage will bear no such construction; that is, what Prof. Tyndall proposes to do is, exactly what all men of science have been about these hundred years. Let us see what he means, which may be the best done by detaching from the address the full statement in which the passage occurs. Prof. Tyndall says: "Two courses, and two only, are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter. If we look at matter as pictured by Democritus, and as defined for generations in our text-books, the absolute impossibility of any form of life coming out of it would be sufficient to render any other hypothesis preferable; but the definitions of matter given in our text-books were intended to cover its purely physical and mechanical properties. And, taught as we have been to regard these definitions as complete, we naturally and rightly reject the monstrous notion that out of *such* matter any form of life could possibly arise. But are the definitions complete? Every thing depends on the answer to be given to this question. Trace the line of life backward, and see it approaching more and more to what we call the purely physical condition. We reach at length those organisms which I have compared to drops of oil suspended in a mixture of alcohol-and-water. We reach the *protogenes* of Haeckel, in which we have 'a type distinguishable from a fragment of albumen only by its finely-granular character.' Can we pause here? We break a magnet, and find two poles in each of its fragments. We continue the process of breaking, but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And, when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that 'Nature is seen to do all things spontaneously of herself, without the meddling of the gods?' or with Bruno, when he declares that Matter is not 'that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb?' The questions here raised are inevitable. They are approaching us with accelerated speed, and it is not a matter of indifference whether they are introduced with reverence or irreverence. Abandoning all disguise, the confession that I feel bound to make before you is, that I prolong the vision backward across the boundary of the experimental evidence, and discern, in that matter which we in our

ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life."

Now, what does Prof. Tyndall here mean by prolonging the intellectual vision across the boundary of the experimental evidence? He has defined exactly what he means, and given an example of it in the case of the magnet, whose broken particles exhibit polarity, "and, when we can break no longer, *we prolong the intellectual vision to the polar molecules.*" That is, molecules and atoms are not objects of sense, and therefore of experiment, but can be cognized only by the intellect. Prof. Tyndall must leave experiment before he can reach them, as they lie far beyond and below all possibility of ever being reached by that method; they are objects of inference, hypothetical creations, and belong to the world of thought. But can it be pretended that they do not also belong to science? All modern physics and chemistry have, for their foundation, conceptions of the molecular constitution of matter. Is the establishment of the great division of molecular physics—is the elaboration of that wonderful system of molecular constructions—the "new chemistry"—an illegitimate and unscientific mental procedure? Was the pious Quaker Dalton guilty of breaking the bounds of science and trespassing upon the territory of religion, when he passed the limits of experimental evidence and reconstructed the atomic theory in accordance with the newly-ascertained laws of chemical action? This must have been so if the charge now made against Prof. Tyndall is valid. And if scientific men are not to be allowed to cross the boundaries of experimental evidence, and reason upon the sub-sensible conditions, powers, and constitution of matter, then there is simply an end to science.

But this is not all. Prof. Tyndall claims that there is a great deal more, in this mysterious and unfathomable something which we call matter, than has been hitherto allowed; he sees in it "the promise and potency of every form and quality of life." Much horror has been expressed at this statement, but the expressions seem to us quite gratuitous. We should like to know what form or quality of life there is, that is not manifested in matter, and is not, therefore, to be ranked among its potentialities. All living things are material things; all organized creatures are constituted of material elements; and, throughout the scale of life, vital, chemical, and physical powers are correlated in inextricable complication, and displayed through a substratum of ponderable constituents. Of the sixty-odd chemical elements, four are chiefly concerned in the maintenance of life; they constitute the mass of all living things, and have long been classified as *organogens*—generators of organization. The mutations of these elements involve the cycles of life. Earth, sea, and air, are filled with myriads of vital forms, and through countless millions of years the earth has swarmed with them, while whole rocky systems are made up of their material remnants. When the microscope was invented, and the frontiers of old observation were crossed, a new world of life was discovered; and, as the powers of the instrument were improved, minuter creatures were disclosed, grade after grade, until organisms were found not the millionth of an inch in diameter. Those who deny spontaneous generation, or that living beings are directly engendered out of matter, are only able to do so by prolonging their vision beyond the sensible evidence, and assuming that Nature is pervaded by infinitely tenuous, inscrutable, though still material life-germs. But, whatever the processes by which Nature breaks into this multitudinous life, it is undoubtedly done through an inflexible system of law. There is no irregularity, caprice, or miracle, about it; it is a phase of

the established order of things, and vital effects can no more be dissociated from the properties and powers of matter than can chemical or physical effects. How far it is possible to unravel the mysteries of life is not the question; how erroneous may be existing theories upon the subject is not now the question. Hypothetical views in relation to it may be false, and the problem itself may be insoluble; but, whether this be so or not, or how far the solution is possible, it is for science alone to determine. Certainly it is not for those who have ever disdained the study of matter to tell us what it can do and what it cannot do, and how far science is to be permitted to go in exploring it. Those who revile matter, and invent insulting epithets to be applied to those who study it, and who consign to execration one of its devoted students for expressing a more exalted sense of its wonderful offices, are evidently not well prepared to instruct us upon the subject.

The theologians are now freely using the harmonies and adaptations of Nature as proofs of wisdom and design on the part of the Creator. But to whom are they indebted for a knowledge of this evidence? To the scientists who have disclosed this order, harmony, and adaptation, by the study of matter. The domain which theology of old allotted to the devil, science has rescued to the service of religion by the revelation of its marvelous powers and capacities; why, then, condemn the scientist if, pushing on his investigation yet further, he claims to discern yet higher potencies and possibilities in this divine material of which the universe is constituted?

MINERAL-COLLECTING.

In accordance with the wishes of many mineral-collectors, who regard the practice in vogue among mineralogists, of exchanging the minerals of their own for those of other localities by a system of barter, as in many respects unsatisfactory and unproductive, Prof. Leeds, of the Stevens Institute, has proposed in a printed circular, a copy of which has been placed in our hands, to discontinue this time-honored custom, and to inaugurate a system of purchase. In accordance with a plan stated in an article entitled "State Geological Surveys," in The Popular Science Monthly of June, 1873, he has collected the minerals occurring within the province in which the institution with which he is connected is located. Quarrymen have been kept constantly employed in blasting for a number of months past, and several thousand specimens have been obtained, all of which have been paid for at the prices usual for this description of labor. It is evident that finely-crystallized minerals collected in this way can be exchanged in the ordinary fashion of barter, only at pecuniary loss in most cases, and nearly always with some measure of dissatisfaction to one or the other party in the transaction. Those who have been most generous and fair in their exchanges have been those who have suffered most. Instead of bartering, the circular announces that prices sufficient to cover the expenses of collecting have been placed upon the specimens, and they are to be sold. The money received from their sale will be devoted to the purchase of specimens for the institute collection, and minerals sent as exchanges must be priced by the senders, and paid for on the same principles as regulate the purchase of chemicals, apparatus, or any other commercial article. For explanatory circulars, catalogues, etc., address Prof. A. R. Leeds, Stevens Institute, Hoboken, New Jersey.

PROFESSOR CAIRNES ON WOMAN SUFFRAGE.

Goldwin Smith's article upon this subject, which was reproduced in the August Monthly, has been replied to in *Macmillan's Magazine*, where it first

appeared, by J. E. Cairnes, the distinguished Professor of Political Economy in University College, London. The article, though a spirited polemic, contributes but little to the radical question, and in our opinion by no means satisfactorily answers Prof. Smith's objections; while we are far from thinking that Mr. Smith himself went to the root of the subject in giving the reasons of his positions. He is of opinion that the extension of political suffrage to the female sex would prove destructive to free institutions, which Prof. Cairnes thinks a groundless and absurd apprehension. But this grave question we believe cannot be determined without going deeper into the subject than either of these writers has done. If the natures of women are the same as those of men, then their enfranchisement might be expected to produce but little change in the course of political affairs; but if women are profoundly different in mental and emotional constitution from men, then the entrance of this new element into the political sphere, by which the voters would be more than doubled, would certainly alter the composition of political forces and the direction of political movement. It is worthy of remark, in passing, that the leading advocates of woman suffrage, while affirming the equality of the sexes and the essential identity of the masculine and feminine mind, nevertheless urge the policy of female enfranchisement on the ground of the numerous new results that would follow, and which would be widely different from those now realized.

There are but two ways of ascertaining what these consequences would be: first, by making the experiment on a national scale and for a lengthened period, because, in the absence of revolution, changes in social and civil types proceed slowly. The second method of ascertaining the consequences of female enfranchisement, and the only practicable method, is, to infer them from the nature of political institutions on one hand, and from the female character on the other. We are here confronted with three scientific problems. We have to consider the natural constitution of society, and find out what are the laws of social change, and the conditions under which social development has thus far taken place. This subject is deeper than politics, which deals with conventional arrangements, and what we may call the superficies of society; and goes down to those relations that underlie all political forms, and pertain to the essential unfolding of humanity. We have also to consider woman in the light of biological science—that is, the physiological nature, modifications, and limitations of her sex; and we have again to study her mental and emotional traits as determined by her biological constitution and maternal experience. These we hold to be the fundamental problems of the woman question, which must be elucidated before there can be any sufficient data for intelligent action; and, until they are more fully elucidated than at present, all action will be but blind and hap-hazard experiments, and far more likely to produce evil than good.

We publish that portion of Prof. Cairnes's article—the most important part—in which he deals with the relation of woman suffrage to the family; but the argument is unsatisfactory. The "element of weakness in the family, as things now stand," he says, is the "want of sufficient subjects of common interest between man and woman;" certainly a most astounding averment. Man and woman in the family mean husband and wife, father and mother, growing children, home-education, the formation of character and the outer social relations that spring from the family circle. The home, by its very constitution, is at the same time the centre of the tenderest and strongest emotions, and the

place where all the faculties of the intellect may be brought into the fullest exercise. From the most trivial questions of the ordering of the household, up to the ever-impending contingencies of life and death, there is occasion for sleepless solicitude, unremitting thought, and extensive knowledge. There is room for the play of the æsthetic faculties and a cultivated taste; there is need of light from various sciences; there is demand for a cautious logic; there is required a direct knowledge of things, as well as of book information, and also a training in practical household concerns. All these are constant and pressing subjects in which both father and mother should be interested and instructed, upon which the very destiny of the family depends. And yet Prof. Cairnes tells us that the present element of weakness in the family is the *want of sufficient subjects of common interest!* He is mistaken; there are subjects enough of mutual concern, but the element of weakness is that they are neglected. He would elevate and strengthen the family by having the women go into politics; we are quite clear that this is not the way the family is to be elevated and improved. Prof. Cairnes's remedy is no remedy at all, and would rather be a fatal hindrance. The general effect would be to preoccupy the female mind with public instead of private and domestic interests; and to divert attention from those home questions which are in fact a thousand times more important to the community than the issues of partisan strife.

THE RIGHTS OF ORIGINALITY.

To fair-minded readers, apology will be unnecessary for the very considerable space that we devote this month to the relation of Herbert Spencer to the doctrine of Evolution: the misconceptions that have prevailed, regarding Mr. Spencer's relation to this great doctrine, make such a statement as this indispensable in the interest of justice. Much of the misunderstanding and erroneous representation is undoubtedly due to the general ignorance of a subject which has recently attained unexpected prominence, and has to be discussed by many who are not well informed about it. For example, in an able and liberal article on Prof. Tyndall's late address, in *Harper's Weekly*, Mr. Darwin is declared to be "the most famous expounder of Evolution." This is so far from being true, that Mr. Darwin has never even attempted any such thing. He has devoted his life to special and important researches, which bear upon the principle of organic development; but his writings, though rich in biological contributions to the question, do not contain any thing like a full or comprehensive exposition of the subject. Whole tracts of the inquiry they do not touch; the general evidence of the truth of Evolution they do not give; nor do they subject the problem to that rigorous analysis into its ultimate elements and factors which scientific investigation requires. Mr. Darwin has shown with great learning how the principle of natural selection gives rise to diversities of organic species; but natural selection is no more Evolution than a fusee is a watch, or a throttle-valve a steam-engine; and *Harper's Weekly* might as well send its readers to a treatise on Arches to get a knowledge of Architecture as to Mr. Darwin's writings to get a knowledge of Evolution. Perhaps no living man is better acquainted with what Mr. Darwin has done than Prof. Huxley; but, in a lecture before the Royal Institution of Great Britain, he said: "The only complete and systematic statement of the doctrine" (Evolution) "with which I am acquainted, is that contained in Mr. Herbert Spencer's 'System of Philosophy,' a work which should be carefully studied by all who desire to know whither scientific thought is tending."

It is to correct errors like this, which are wide-spread and do serious injustice to Mr. Spencer, that we have thought it necessary to go carefully into the subject, and furnish the evidence on which Mr. Spencer's claims to originality are founded.

PHOTOGRAPHY AND THE CHEMICAL CENTENNIAL.

It was fitting that, at the Priestley centennial of the discovery of oxygen gas, two of the grandest achievements of modern science should have been called into requisition, to make the event known far beyond the circle of those who participated in the occasion. The telegraph reported the doings to all the contemporary world who cared about them, and the photograph preserved many of its interesting features pictorially, for the benefit of future generations. It was the general wish of those present that photographs should be made of the house which Dr. Priestley built and in which he died, and of the collections of his scientific apparatus. We are happy to see that this desire has been complied with, and a series of pictures taken, which represent the objects of chief interest in the celebration. No. I. is a group of chemists, representing 72 figures of the scientific men who attended the centennial meeting; No. II. Dr. Priestley's residence, showing the house and laboratory; No. III. Copy of a rare old engraving, showing the fury of the mob which destroyed Priestley's house in Birmingham; No. IV. Priestley's chemical apparatus; No. V. His electrical apparatus; No. VI. His physical apparatus. These three groups are from the Loan Exhibition. No. VII. Interior view of the Loan Exhibition; No. VIII. Headstone of Priestley's grave. These photographs are mounted on eight by ten Bristol board, price 50 cents each, or $3.50 for the set of eight. They may be ordered from Louis H. Laudy, School of Mines, Columbia College, New York.

LITERARY NOTICES.

The Building of a Brain. By Edward H. Clarke, M. D. 153 pages. Price, $1.25. Boston: J. R. Osgood & Co.

Dr. Clarke did the country a service last year, by publishing his little volume entitled "Sex in Education," in which he called attention to some physiological points in the school-experience of girls, in such a way as to provoke half a score of replies, and to bring the subject very effectually before the public. He took ground against co-education, or the subjection of girls to the same conditions of study as boys, and showed how that system works serious and extensive injuries to the female constitution. The little volume now issued, while it is not a formal reply to his critics, pursues the subject of the physiological basis of education. Instead of dealing with mind as an abstraction, he takes up the brain in which it is embodied, and shows how mental development is, at bottom, really a process of "brain-building." Metaphysical vagueness is here escaped, and we have to deal with tangible and definite results that are dependent upon established laws. The body is thus brought into account, and we see how education, or mental development, is so deeply complicated with physiological conditions, that these can never be neglected in the intelligent consideration of mental culture.

At the close of this special essay, Dr. Clarke appends a mass of valuable testimony in regard to the practical workings of the system of co-education. The short article in our preceding pages, which we have entitled "Educated to Death," is taken from this portion of Dr. Clarke's book. By direction of the State Board of Health of Massachusetts, Dr. F. Winsor, of Winchester, collected some valuable statistics on "School Hygiene," and the effects of co-education formed one feature of the investigation. Circulars were sent to physicians, teachers, and others in the State, soliciting information in answer to questions. Replies were received from one hundred and sixty persons, of whom one hundred and fifteen are stated to be physicians; nineteen, physicians and members of school commit-

tees; fourteen, teachers of experience, and six, superintendents of schools. The Board requested that all the replies should be "based on personal observation." The question, "Is one sex more liable than the other to suffer in health from attendance on school?" was answered substantially as follows:

Females more liable than males, by	109
Males more liable than females, by	1
Both alike liable, by	81
Neither is in danger, by	4
Not in district schools, by	1
Not if both sexes exercise alike in the open air, by	1
Unable to answer, by	5

To the question, "Does the advent of puberty increase this liability?" the answers came:

Yes, by	120
No, by	12
Uncertain, by	9

Many of the correspondents accompanied their replies with comments which were mostly in the following strain:

"The female scholars are more susceptible to emotional influences, and if there be stimuli in school, appealing to pride and vanity, they are so emulous as to injure themselves."

Again: "This baleful result becomes very strikingly manifested as the girls approach the age of puberty. Under the abnormal conditions of the physical system produced by this cause, not only do the more emulous and studious girls suffer from the study which they evidently ought to intermit, but the ordinary and habitual task-work necessary to keep abreast of the studies is far too severe a draught on many constitutions."

Again: "This greater liability in the female is an *established fact;* and our State and local School Boards should at once take steps to modify our system of education in accordance with the fact, however great may be the change required."

From various communications received by Dr. Clarke with reference to the workings of co-education, we extract the following from that of D. H. Cochran, LL. D., the distinguished head of the Brooklyn Collegiate and Polytechnic Institute, who had ten years' experience of co-education in the New York State Normal School. Dr. Cochran says it had been observed that a large number of students who left the institution were unfitted for teaching by impaired health, so that Dr. Woolworth made an appeal to the commissioners "to send only such students to the school as possessed a sound physical organization. . . .

"Notwithstanding his earnest efforts, the evils of failing health on the part of our female pupils continued, and the consequent incapacity to discharge the duties for which the State was educating them. But the facts were hardly suspected until suggested accidentally, in 1866, and then the reports of Dr. Bailey, who had been consulted by a large number of the female pupils, and of a lady in the faculty of the school, revealed the astounding fact that, among about one hundred and eighty female pupils then in the school, there were over twenty cases in which the periodical functions peculiar to the sex had ceased for over two months, and that there was a much larger number of similar cases, less serious. Even then, the causes were attributed to stairs, bad ventilation, and recklessness of health, without suspicion that the evils were inherent in a system which imposed upon the female continuous labor, and in amount equal to that of the male, who was in many, and perhaps in the majority of cases, her intellectual inferior, but who was the inheritor of continuously rugged health. . . .

"The logic of facts, to which our eyes were so slowly, and I fear unwillingly, opened, finally led to a more elastic course, optional to the females. But, while this gave relief to a part of the pupils, it augmented the evils to others; for the more ambitious regarded the exemption from advanced mathematics as a reflection upon their intellectual ability, and persisted in taking the severer course in spite of the advice of their teachers. . . .

"This spirit was indicated in the remark of one of these pupils to a lady-teacher who was advising her to drop the mathematics of the senior year, on account of failing health. She said, 'I will do it, if it kills me.' We can hardly wonder that the teacher impatiently replied: 'If it killed you, perhaps it would not so much matter; but are you quite willing to impose upon your

friends the burden of your lifelong helplessness?'

"I urge the separate higher education of females solely upon physical grounds. My experience has forced me to this. I have a record of my former pupils who stood high in their classes, who did their work with seeming ease, but who have been unable to teach, and now confess that they date the beginning of their present sufferings to the continuous labor of school. I have in my mind, as I write, the case of a young lady from Tioga County, now residing in this city, who stood foremost in her class, and without apparent effort, but who has never been in sound health since her graduation; and she attributes her present condition to the insensible exhaustion of her class-work. Yet she would have been the very last to confess overwork while a pupil; and I do not think that either she, or her teachers, then suspected it."

L'Astronomie Pratique et les Observatoires en Europe et en Amérique depuis le Milieu du XVII^e^ Siècle jusqu'à nos Jours. Par C. André et G. Rayet, Astronomes Adjoints de l'Observatoire de Paris. Première partie.—Angleterre. Paris: Gauthier-Villars, 1874.

(Practical Astronomy and the Observatories of Europe and America, from the Middle of the Seventeenth Century until the Present Time. By André and Rayet, Assistant Astronomers in the Paris Observatory. Part I.—England.)

This is the first of a series of three volumes to be published for the joint authors, who are both skillful and able astronomers, known in the scientific world by various important researches. This volume treats of the observatories of England alone, and it is to be followed by two others treating of those of Scotland, Ireland, the Continent, and America.

The design of the work is most excellent, and its execution is thoroughly good, as indeed might have been anticipated. In brief, the plan of the authors has been to give a short history of each of the many institutions devoted to practical astronomy, with a sketch of the life and works of each of the directors who has been in charge of it, as well as an account of the principal instruments and the uses to which they have been devoted.

Quite a number of very good woodcuts are supplied, which give perspective views of some of the most important instruments, and these alone lend great value to the book. Many of these cuts are derived from engravings given in the publications of the various observatories, and they are therefore accessible to all who can consult any of the great libraries; but the collection of these into one volume is a great convenience.

Quite a number of the cuts, however, must have been copied from photographs privately distributed, which, of course, are not generally accessible, nor widely known, and for the reproduction of these we cannot be too grateful. We may instance the extremely interesting cut of Mr. Newall's great telescope of 25 inches aperture (made by Cooke, of York), which was the largest refractor in the world until the mounting of the Clark telescope at the United States Naval Observatory at Washington, in 1873.

A propos of large telescopes, the authors tell us that the two large disks of glass (30 inches in diameter) which have been in the possession of the Paris Observatory since 1855, are shortly to be ground into lenses and mounted, so that, provided the operation of grinding is successful, and no unknown flaws in the glass exist, Paris will soon have a larger equatorial than any now mounted.

Americans, however, may console themselves with the thought that the magnificent gift of Mr. Lick, of San Francisco ($700,000), will soon become available "to construct a more powerful telescope than any now in the world," and they may safely trust to the artistic skill and to the scientific sagacity of the Clarks, to whom the work will undoubtedly be confided, to make the most perfect instrument yet known.

The book treats largely, too, of the history of the private observatories of England, and it is no small convenience to have gathered into one volume material which, if in print at all, is scattered through many volumes of rare periodicals and books.

In this volume 50 pages are devoted to the Observatory of Greenwich alone, and then follow accounts of those observatories which belong to universities, to learned

societies, or to cities; and, finally, 80 pages are concerned with the observatories of private gentlemen.

It will be seen that this is a very full account, and we may say that, besides being a book of great interest to the astronomer, it will be highly interesting to the general reader who is anxious to be informed about this important subject.

We notice very few omissions: the most striking one, however, is the absence of any account of the Bedford Observatory, of Admiral Smyth, which should be notable if only as the birthplace of the "Bedford Catalogue," one of the most curious of astronomical publications.

Perhaps the omission of the celebrated catalogue of "Double Stars" from among the works of Mr. Dawes, the noted observer of double stars, might also be mentioned.

But these are minor points, and do not prevent the book from being a perfect success, creditable to its authors, and a valuable contribution to the literature of astronomy.

We look forward with eagerness to the appearance of the remaining two volumes.

It is to be hoped that the book, or at least that part of it which refers to the observatories in the United States, may be translated into English, for the use and information of many Americans who will not see the original French edition.

Since Loomis's "Recent Progress of Astronomy in the United States," nothing of importance has been published here, on this subject, if we except two papers on observatories in the United States, which have recently appeared in *Harper's Magazine*.

There undoubtedly exists among Americans a very strong interest in astronomy generally and in the doings of observatories, and a greater knowledge of the many institutions of this kind in the United States would undoubtedly lead to more intelligent and concerted action on the part of the private gentlemen who own them.

For example, if a person who has a fine meridian instrument knows that the Harvard-College Observatory is observing a certain zone of stars, he will not commit the folly of wasting his time and his labor by doing the same work, but will rather turn his attention to something which is yet undone. To know what is yet undone is often the question, and this book supplies in a measure the want, for it tells us what is doing.

Perhaps this is as good a place as any to call the attention of amateur astronomers to the important work which they may do, if they will only choose some special subject, make themselves familiar with what has been done in it, and then devote even a small portion of time to its *regular* and *systematic* pursuit.

Numerous examples of such valuable work done by amateurs are to be found in the book before us: and in many cases this work was done by gentlemen who were not able to devote their whole time, or any thing like it, to astronomy.

Dawes, the great double-star observer; Carrington, the assiduous observer of circumpolar stars, and of solar spots; Lassell, the great physical astronomer; with De La Rue, Huggins, Lockyer, and others, have done permanent good to science, and have acquired great reputation, while most of them followed other pursuits.

And we may hope that such knowledge as is attainable from this book will induce American amateurs to limit themselves to some useful but special inquiry in which they may gain credit, and render useful service to astronomy. E. A. H.

THE JOURNAL OF SPECULATIVE PHILOSOPHY, July, 1874. Quarterly, whole number 31. Price 50 cts. a number, or $2 a year. Edited and published by WILLIAM T. HARRIS, St. Louis, Mo.

THIS periodical, which has come to be recognized as the organ of speculative thought in this country, has now reached its eighth volume, and the series forms a philosophical library of great value to metaphysical students who keep up their interest in abstract and abstruse inquiries. It is the policy of the editor to make his periodical not so much a vehicle of contemporary speculation as a summary of the doctrines and expositions of the greatest philosophical thinkers of past times. Accordingly, the published volumes will be found largely occupied by essays and discussions from the writings of such men as Leibnitz, Descartes, Kant, Fichte, Schelling, Hegel, Goethe, Rosenkrantz, Schopenhauer, Hartmann, Herder, Trendellenburg, and others. From such

writers we have in the pages of this magazine an authoritative and all-sided presentation of metaphysical questions, such as can be otherwise obtained only by ransacking extensive libraries. An important feature of the magazine is the considerable space it devotes to the criticism and interpretation of the works of art, poetic, dramatic, musical, pictorial, architectural, etc.

The first article of the July number of this magazine is an addition to the voluminous literature of Shakespearean criticism, by D. J. Snider. In an acute and ingenious analysis of "The Tempest" the author aims to show that this drama is a profound philosophical study of two worlds, the real and the ideal. As it is latterly the fashion for lawyers, doctors, and scientists, to find every thing in Shakespeare as fast as it is discovered elsewhere, so the present writer would seem to assume that the poet had anticipated the last results of German metaphysics. Will not this vein at length give out? Daniel Wilson has lately been over the same ground, and devoted a solid volume to prove that in "The Tempest" Shakespeare has anticipated the modern doctrine of Evolution. Among the questions debated by the schoolmen of the middle ages, the following is reported: "Was Adam, while yet without sin, acquainted with the '*Liber Sententiarum*' of Peter Lombardus, Bishop of Paris?" It would seem to be an open question with many of our later commentators and schoolmen, whether Shakespeare may not really have been acquainted with the works of Darwin and Hegel! "The Music of Color," the second article, is an ingenious and instructive statement of the analogies of light and sound as explicable on the wave-theory. Many efforts have been before made to find harmonic relations between the spectrum and the gamut, but the results have been regarded as unsatisfactory. The present writer presses the analogy in many particulars, and is confident that it will ultimately be fully established. In the third article Prof. Vera treats of "Ideas as the Essences of Things." He takes the high Platonic ground of independent and eternal ideals, saying: "The force that produces the plant, and according to which the plant grows and dies, is its idea. The real and absolute germ is not the individual and external germ we touch and see, but the idea by which the external germ is created and endowed with the necessary force for its growth and preservation." "Thoughts on the Intellect" is a translation from one of the powerful works of Schopenhauer, in which that pestilent old pessimist puts the entire philosophy of things in the following nut-shell: "The laws and powers of Nature, together with matter in which they inhere, constitute here the given, and consequently the absolute real, taken generally; but regarded specially, as innumerable suns and planets, floating in infinite space. These are therefore, as the result, everywhere, nothing but balls, a part of which are shining, the rest illuminated. Upon the last, life has unfolded itself in consequence of a process of putrefaction, which, in gradual succession, produces temporary organic beings, rising and perishing through generation and death according to the laws of Nature governing the power of life, which, like all the others, make up the reigning (and from eternity to eternity) existing order of things, without beginning or end, and without giving account of themselves. The highest point of this succession is occupied by man, whose existence also has a beginning, in its course many and great miseries, few and parsimoniously-granted joys, and after this, like every thing, has an end; after which, it is as if it never had been."

Mr. Stephen Pearl Andrews contributes a paper on the "Revisal of Kant's Categories." He is the author, as is well known, of an elaborate philosophical system which he denominates "Universology," and one of the features of which is a universal language. Mr. Andrews is a philosophical linguist, and his studies have brought him to the conclusion that there can be no comprehensive and perfected system of philosophic thought that does not include some means of systematic security against the errors which arise from the defects of language and the multiplicity of tongues. In the present paper he takes the "categories" arrived at by the transcendental analysis of Kant, and seeks for those elements and conditions of the structure of language which correspond to these categories. He says: "The three categories of quantity are Unity, Manifoldness, and Universality, which are no

more than the same ideas which, in respect to grammar, we indicate by the terms 'singular, plural, and common.'" He then proceeds to trace out other analogies or correspondences, and shows that grammar throughout has its true basis in logic.

The number before us of the *Journal of Speculative Philosophy* contains other articles, as an analysis of the music of "Robert Schumann," Herbart's "Rational Psychology," and various minor discussions, but the essays noticed will give an idea of the scope and variety of the subjects treated in its pages. If it be thought that this magazine is too sublimated in its speculations for practical service in this age, we must remember that the age needs improving; that the tendency of all science is toward the establishment of generalizations or abstract principles; and we must not forget that this journal is edited by one of the most able and thorough of the practical educators of the country.

ONE YEAR OF SCIENCE. Tribune Publication. Price, 25 cts. Contents: Scientific Views of Comets; Philological Convention of Hartford; Chemistry's Centennial; American Science Association of Hartford.

THIS pamphlet of 92 large pages, double columns and in small type, contains an immense amount of miscellaneous scientific information boiled down to a state of concentration that is only equaled by the cheapness for which the whole is sold. There are nearly 150 articles, many of them quite full, some of them illustrated, and all of them on the latest aspects, results, and tendencies of contemporary science. In its series of cheap scientific publications, freighted with useful information for the people, the *Tribune* is doing an important work of popular education, and deserves to be widely and liberally sustained.

EXPOSURES IN FIRE-INSURANCE. By WILLIAM FRAZIER ROSS. New York: D. Appleton & Co.

IN the language of fire-insurance, all insurable property is subject to certain exposures or liabilities to take fire. For instance, a building so situated in relation to a storehouse of oils or spirits, that, were the liquids to take fire, they would flow toward it, is therein subject to an exposure. Exposures are numerous and varied in kind, and upon the number and quality of those to which a building is subjected does its rate of premium depend. This makes apparent the necessity for a reliable method of estimating the exposures. The difficulty hitherto in the way has been want of statistics, and this deficiency it is the object of this little volume to supply. In the main, it fulfills its purpose, but the habitual use of technical terms, without explanation of their meaning, and the occasional occurrence in close proximity of a word, first in its technical and then in its common acceptation, is calculated to confuse the general reader. By its use, property-holders will be enabled to estimate for themselves the cost of insuring their property, and thus to establish a check on over-charges.

AN INTRODUCTION TO THE STUDY OF GENERAL BIOLOGY. By THOMAS C. MACGINLEY. New York: G. P. Putnam's Sons. 198 pages. Price, 75 cents.

THIS is an ambitious attempt to supply what is still needed—a good text-book on biology for schools. The author deals extensively with the torula, or yeast-plant, bacterium, protococcus, and other low forms of life, and gives but a single example of the three highest branches. In this respect the subject-matter of the book is not properly balanced. While there is much to commend, there is much to object to in the obscure and shocking character of many of the figures, as being more likely to mislead than to aid. Many of them look faithful copies of hasty and crude pencil-notes of hasty and crude drawings made on the black-board.

STATISTICAL ATLAS OF THE UNITED STATES. Part II. Population, Social and Industrial Statistics.

THIS is part of a series of large folio maps intended to represent, graphically, first the progress of the United States, both as regards acquisition of territory and increase of population, and then the relative proportions of the various race-elements. To the illustration of these subjects are devoted sixteen sheets of the atlas. The remaining eleven sheets represent the ratio

to total population of illiteracy, of church accommodation, of producers, etc., and the distribution of wealth, public indebtedness, taxation, revenue, expenditures, and agricultural products.

THE TRANSIT OF VENUS. By GEORGE FORBES, B. A. Macmillan & Co. 99 pages. Price, $1.25.

THIS timely little volume was contributed in installments to *Nature*, and these are now collected and issued in the neat form of Macmillan's "Nature Series." It gives an interesting account of the general subject, first, in its historical aspect; second, the scientific conditions of the problem; third, the preparations for solving it by the different nations. The volume is copiously illustrated, and will meet the wants of general readers who wish to know something about the great scientific event that is to happen in December. At the close of the third chapter, the author thus recapitulates the technical view of the subject:

"1. We know the *relative dimensions* of the solar system accurately; but we do not know the *scale*.

"2. The determination of the distance of the earth from the sun, or from any of the planets, at a fixed date, fixes the scale.

"3. This may be determined (1) by the aid of a transit of Venus; (2) by an opposition of Mars; (3) by a knowledge of the velocity of light, combined with observations of eclipses of Jupiter's satellites; (4) by the velocity of light and the constant of aberration; (5) by the calculated effects of the sun's disturbance upon the lunar motions.

"4. A transit of Venus may be utilized:

"(*a.*) By the determination of times of contact at different stations, combined with a knowledge of the longitudes of these stations.

"(*b.*) By determining the least distance between the centres of the sun and Venus during the transit, observed from different stations.

"5. This last determination may be made by any of these methods:

"(1.) The photographic method.

"(2.) The heliometric method.

"(3.) The method of durations."

A WORK OF GREAT IMPORTANCE.—The twelfth volume of the "International Scientific Series" is contributed by Dr. John W. Draper, and will be a "History of the Conflict between Religion and Science." It might seem strange that such a history has never been written before, but the subject has had to wait for the historian. It is doubtful if there is another man living besides Dr. Draper who has had the peculiar preparation necessary for executing so difficult a task. Dr. Draper's familiarity with science is extensive. He has cultivated large tracts of it as an original investigator, and with a success that has given him a world-wide reputation. He has also been a life-long student of history, and has considered his questions largely from his point of view as a student of Nature. Dr. Draper's "History of the Intellectual Development of Europe" is one of the great books of this age; and that it is so appreciated is shown by the fact that it has been translated into nearly all the languages of Europe. The study of the problem of the intellectual development of man which has taken place in Europe in historic times, was a grand preparation for treating the special relations of religion and science in their historic aspects. The volume is written in a remarkably clear and attractive style, suitable for all readers, and it abounds in fresh and striking views, vividly and boldly presented. Dr. Draper's book is certain to make a profound impression upon the public mind.

PROFESSOR TYNDALL'S BELFAST ADDRESS. With Preface and Additions, by the author. First authorized and revised edition. D. Appleton & Co. 68 pages. Price, 25 cents.

IN the Preface to this complete edition of his Address, Prof. Tyndall says that it was written in the Alps, and was sent home in installments to be printed; but, being too long for oral delivery, he was compelled to omit certain parts, while only what he read was given to the public. The omitted passages are now supplied, the whole has been thoroughly revised, and a Preface is added in which the Professor pays his respects to some of his detractors. Regarding one of these imputations, he says: "In connection with the charge of atheism, I would

make one remark. Christian men are proved by their writings to have their hour of weakness and of doubt, as well as their hours of strength and of conviction; and men like myself share, in their own way, these variations of mood and tense. Were the religious views of many of my assailants the only alternative ones, I do not know how strong the claims of the doctrine of 'material atheism' upon my allegiance might be. Probably they would be very strong. But, as it is, I have noticed, during years of self-observation, that it is not in hours of clearness and vigor that this doctrine commends itself to my mind; that in the presence of stronger and healthier thought it ever dissolves and disappears, as offering no solution of the mystery in which we dwell, and of which we form a part."

PUBLICATIONS RECEIVED.

Geological Survey of Indiana. By E. T. Cox. Pp. 494.

Yellow Fever Epidemic of 1873. By Jerome Cochran, M. D. Montgomery, Ala. 1874. Pp. 115.

Bulletin of the Buffalo Society of Natural Sciences. Vol. II., No. 2. Pp. 40.

Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. 1873–'74. Pp. 254.

Double Stars. By S. W. Burnham, Esq. Pp. 13.

Catalogue of Forty-seven New Double Stars (same author).

Molecular Change in Iron and Steel by Electric Currents. By John Trowbridge. Pp. 10.

Freeing a Magnetic Bar from Earth's Magnetism (same author). Pp. 8.

Increase of Magnetism in Soft Iron by Reversal of Magnetizing Current. By W. A. Burnham. Pp. 9.

MISCELLANY.

Artificial Butter.—The *American Chemist* for April contains a very full account of the manufacture of artificial butter, of which the following is a synopsis: Some years ago M. Mege Mouriez was commissioned by the French Government to make some researches with a view to obtain a product suitable to take the place of ordinary butter, to be sold at a much lower price, and capable of being kept without becoming rancid. M. Mege Mouriez placed several milch-cows on a strict diet. The animals were quickly reduced in weight, and gave a proportionately less amount of milk; but this milk always contained butter. Where could it come from? M. Mege Mouriez believed it was produced from the fat of the animal, which, being carried into the circulation, was deprived of its stearine by respiratory combustion, and furnished its oleo-margarine to the udder, and there, under the influence of the mammary pepsin, it was changed into butyric oleo-margarine, or butter. Guided by this observation, M. Mege Mouriez was not long in obtaining, by an ingenious process, from beef-suet a fat fusible at nearly the same temperature as butter, and of agreeable taste. He then transformed this same fat into butter by a process similar to that of Nature. His process is as follows: The fat of newly-slaughtered beef, of the best quality, is ground up between two cylinders, and then falls into a deep vat heated by steam, and containing for every 1,000 kilogrammes of fat, 300 kilogrammes of water, and one kilogramme of potassic carbonate, besides two sheep's or pigs' stomachs in small pieces. The temperature is then raised to 45° Cent. and the mass carefully stirred. At the end of two hours the fat all rises to the surface. It is then let off into another vat, heated on a water-bath to 30° or 40° Cent., and two per cent. of sea-salt added, to facilitate the depuration. In the course of two hours it becomes clear, and presents a fine yellow color, and the odor of freshly-churned butter. Having been carefully cooled, it is cut into cakes, packed in linen, and placed under an hydraulic press, and is then separated into two nearly equal parts, viz., stearine and liquid oleo-margarine. The stearine is used for making candles. After cooling, the oleo-margarine is passed through cylinders under a shower of water to wash it and give it consistence: it constitutes an excellent cooking-grease.

It is with oleo-margarine that M. Mege Mouriez, by operating in the following man-

ner, makes his cheap butter: To 50 kilogrammes of melted oleo-magarine in a churn he adds about 25 litres (26 quarts) of cow's milk and 25 kilogrammes of water containing the soluble parts of 100 grains of the mammary gland of the cow. The churn is then set in motion, and in fifteen minutes the grease and water become transformed into a thick cream, which in turn is changed into butter. The churning being ended, water is poured in and the butter separates, containing buttermilk, which must be removed. The product is then placed in a sort of kneading-machine composed of two cylindrical crushers, and placed under a stream of water. There it is worked in a way to change it "into well-washed butter of fine and homogeneous appearance."

The Todas.—A traveler in Southern India, Colonel Wm. Marshall, in a work recently published, makes the world acquainted with a very singular tribe of men, the Todas, who inhabit the plateau of the Nilghiri Hills. The Todas live in very small village communities of from twenty to thirty persons. Attached to every village is a cattle-pen, and a separate building, which constitutes the dairy and the dairyman's abode. Their life is purely pastoral, and their sole dependence the buffalo. Though the land is fertile and the climate delightful, they do not practise agriculture at all; and though their hills abound in game, they neither hunt nor trap any living thing. Their only domestic animals are the buffalo and the cat. They eat no flesh, living wholly on milk and butter, with rice and other vegetable food obtained in exchange from the surrounding population. Though on all sides they are hemmed in by strong and often quarrelsome tribes, they possess no weapon of offense; they never fight among themselves or with their neighbors. They have no manufactures. Two men in every village are set apart for the dairy-work, leaving all the rest to lead an almost absolutely idle life. The Todas are quiet and dignified in their manners, amiable in disposition, and very good-looking. Their absolute dependence on the buffalo has led them to form a religion in which this animal is the central figure. The dairy is sacred, and no one except the dairyman and his assistant is permitted to enter it. During the term of office these two men have to pass absolutely retired and celibate lives, they and their implements being touched by no human being. They keep in the dairy certain relics—old cow-bells, knives, and axes—which are in the highest degree holy, and these the dairyman-priest salutes every morning with certain ceremonies. The people in general also salute the setting sun, and have some vague notions of a future state.

The Todas number at present only about seven hundred souls. Formerly they practised infanticide, but for some years this has ceased, and the tribe is now increasing in number. The primitive custom was to kill all female children of a family except one or two. The result was of course an excess of males, and hence sprung the custom of one woman having many husbands. This practice still continues. The census tables seem to show that considerably more male than female children are born. It is worthy of note that, although from time immemorial consanguineous marriage has been the rule among the Todas, still not more than one per cent. are malformed.

Tea-Adulterations.—One of the usual ways of adulterating tea is by the admixture of leaves other than those of the tea-plant. For the detection of these foreign leaves, but little aid can be given by chemistry, and it is best to study their botanical and microscopical characters. Prof. Alfred H. Allen gives, in the *Chemical News*, the following method for detecting adulterations of this kind: "Some of the sample to be examined," says he, "is to be put in hot water, and when the leaves have unfolded, they are spread out on a glass plate and held up to the light, when the venation, serration, etc., are readily observed. The primary venation of the tea-leaf forms a series of well-defined loops, which are not met with in most leaves used as adulterants. The serrations are not mere saw-teeth on the margin of the leaf, but actual hooks. The serration stops short, somewhat abruptly, at some distance above the base. The Assam tea-leaf is sometimes bi-serrate. At the apex of the tea-leaf there is a distinct notch, instead of a point. If we ex-

amine the under surface with the microscope after the separation of the cuticle, the peculiar and characteristic space between the two cells of the stomata is readily perceived. The long unicellular hairs of the tea-leaf are also peculiar. The employment of caustic potash is desirable in observing these characters.

"In the *sloe-leaf* the serratures are direct incisions, numerous, often irregular, and extending down to the base. There are no spines. The hairs are shorter and coarser than those of the tea-leaf, and are marked in a peculiar manner. The *elder-leaf* is more pointed than that of the tea-plant, and the lobes are unequal at the base. The serratures are direct incisions. The midriff has hairs on it, and on the leaf itself there are several kinds of hairs, notably a short, spinous, striated hair, which occurs on the upper surface. The serratures of the *willow-leaf* much resemble those of tea, but the cell-walls of both the upper and under epidermis differ from those of the tea-leaf in not being sinuous, and there are long, coarse, striated hairs. When perfect, the elongated form of the willow-leaf sufficiently distinguishes it from tea, and the venation is also entirely different. The chief foreign leaves added by the Chinese are those of *Chloranthus inconspicuus* and of *Camellia sasanqua*, the latter of which presents a close resemblance to the tea plant."

Usefulness of the Robin.—Pitying the ignorance of farmers, and country-people generally, touching the habits and usefulness of the robin, and pitying equally the poor bird itself for the abuse which this ignorance brings upon it, Caroline Bryce, in the April *Naturalist*, has rendered a service to both by pointing out in a very interesting way the value of the bird to the country, and the mistake that is made in attempting to drive it from our fields and groves. "The robin has two broods in a season, each brood varying in number from two to five. The young are fed exclusively on insects, and their rapid growth and consequent voracity, only equaled by the larvæ stage of insect-life, makes an abundant supply of insect-food an indispensable requirement. The food of the mother-bird is also chiefly insects, and this double demand makes the robin a valuable assistant to the farmer and horticulturist in keeping under insect pests. Regarding its supposed habit of cherry-eating, the author is of opinion that it is attracted chiefly by the color of the fruit, and not by any special liking for it as food; that it picks the cherries for the same reason that it picks to pieces a red flower. Instead of being an enemy to the cherry-crop, it is in reality a most important aid in securing an abundant supply of healthy fruit. If I should venture to say that not a cherry would grow, fit to be eaten, were it not for the birds, the bare idea would be hooted as preposterous, yet such, nevertheless, is my belief. Were it possible to remove all the birds out of the way, for one season at least, what a decided difference would our future orchards present! Where now are thrifty growths, beautiful leafage, and large crops of fair fruit, would be seen stinted, moss-grown limbs, with sparse or meagre foliage, crops of dwarfed specimens, that have finished their growing, in a knotty, wormy, inferior state. The majority of all the large families of insects are bred in the earth, and go through various forms in different stages of existence, and are devoured by birds of every description, chief among which stands our friend the robin."

How Leaves are blanched by Bright Sunlight. — The leaves of certain plants grow pale in the full glare of the sun, and it becomes a question whether this change is due to a diminution of the amount of chlorophyll. Mr. H. C. Sorby has repeatedly analyzed the leaves of such plants, but the result showed that sunlight or shade makes no difference in the quantity of the chlorophyll. He therefore came to the conclusion that the change in color is due to some mechanical alteration in the structure of the leaves. This conclusion is confirmed by the independent researches of a French observer, Prillieux. According to the latter, exposure to bright light causes both granular and amorphous chlorophyll to collect together at the sides of the cells, instead of being more evenly distributed. The result is, that a much larger relative quantity of white light is reflected, and the leaves appear of a paler and whiter green.

Fossil Horses.—In the *American Naturalist* for May, Prof. O. C. Marsh has an article on "Fossil Horses in America," in which he says that the remains of equine mammals hitherto found in the Tertiary and Quaternary deposits of this country represent more than double the number of genera and species occurring in the strata of the Eastern Hemisphere. It is in ancient lake-basins of Wyoming and Utah that the oldest equine remains have been found. These belong to the genus *Orohippus*, and are of diminutive size, hardly larger than a fox. The skeleton of these animals resembled that of the horse in many respects, but, instead of a single toe on each foot, the various species of *Orohippus* had four toes before and three behind, all of them reaching the ground. Of *Orohippus* Prof. Marsh has found four distinct species. The genus *Miohippus* makes its first appearance in the Oregon basin. It is distinguished from the *Orohippus* chiefly in that it has only three toes in the fore-foot, as well as behind. In this genus all the toes reached the ground. In the same deposits the genus *Anchitherium* occurs, being represented by a single species. The animals of these two genera are all larger than *Orohippus*, some of them exceeding a sheep in size. Of the Pliocene genera more than twenty species have been described, all apparently larger than their Miocene relatives just mentioned, but all smaller than the present horse. In the Upper Pliocene, or more probably in the transition beds above, there first appears a true *Equus*, and, in the Quaternary, remains of this genus are not uncommon. Thus there is a continuous development in the direction of the modern horse, and it seems very strange that none of the species should have survived.

Tidal Influence on Vegetable and Animal Life.—The following dispatch was sent by A. N. Duffre, United States consul at Cadiz, Spain, and communicated to the Department of Agriculture by the Secretary of State:

A Madrid paper, entitled *La Epoca*, has published an article signed by Don Luis Alvarez Alvistur, on the influence of the tides on vegetation, in which the writer announces a new theory, based on the results obtained during fourteen years devoted to experimental research, by an enlightened landed proprietor of Lorca, in the province of Murcia.

The theory adopted was the direct influence of the tide on the circulation of the sap, and its experimental application, after determining the meridian of the estate, and tabulating the corresponding hours of ebb and flow, has been the felling and lopping of forest-trees solely during the hours pertaining to the ebbing tide. The results are stated to have been conclusive, the decay annually observable formerly in some portion of the timber having ceased completely in the many years that have elapsed during the application of the new principle. The system was then applied to an olive-grove, the yield of which had ceased to cover the annual costs of culture, by removing every dried portion of the trees exclusively during ebb-tide. The result is stated to have been the complete transformation of the grove, a great development of foliage, and abundant crops.

Equally admirable results ensued from the similar treatment of orange, lime, and other fruit-trees, which were thenceforth unaffected by larvæ or other plagues which smote adjoining orchards; and, finally, the vineyard of the Lorca landlord, though surrounded by those of other proprietors which were devastated by the *oidium*, a microscopic fungus which appeared in the district at the period when the new system was first essayed, has never exhibited the faintest trace of the presence of the malady.

It is likewise asserted that experiments, made with equal sets of silk-worms, respectively fed on leaves of trees treated by the ordinary and by the new system, the leaves under the new plan being gathered exclusively at the hours corresponding to the ebb-tide, resulted most decidedly in favor of the latter.

How the Fuegians keep warm.—In "A Memoir of Richard Williams," an English missionary to Patagonia, occurs the following passage:

"When clothing is scanty, by the same providential management which coats the whale in frozen seas with oil, the Fuegian

is fortified against his inclement sky by an abundant development of the adipose tissue; and, though his sea-otter or guanaco cloak is somewhat scanty, in admiring his handiwork, we must not forget that inside his skin he wears a thick underclothing of non-conducting fat. Hence these islanders sometimes exhibit feats, the recital of which is enough to make us shiver. In the coldest midwinter they may be seen diving for sea-eggs; and it was on a dark night, when the thermometer was at 25°, that some of them swam from the shore, and from its mooring alongside cut away the ship's boat of the Adelaide."

Drought and the Potato-Disease.—A writer in the *Gardeners' Chronicle* observes that every outbreak of the potato-disease, since 1845, has been preceded by a long term of dry, warm weather, followed by heavy rain late in July, or during August. Hence he concludes that this disease must be caused by the carbonic, sulphuric, nitric, and other acid matters, which are constantly accumulating in the atmosphere during dry weather, until they unite with showers of rain, by means of which they are deposited upon plants and soil. As the leaves of plants are their lungs, and the potato is a tender plant, the poisonous atmospheric acids of summer droughts, thrown down by heavy rains, quickly act upon the holms. The surest remedy appears to be, to dig the potatoes, and store them before the summer rain commences, provided they are nearly ripe—that is, when the stalks begin to wither, or when the skin of the tuber cannot be rubbed off with the thumb.

NOTES.

During the Khivan expedition, the Russian army was fed chiefly on biscuits composed one-third of rye-flour, one-third of beef reduced to powder, and one-third of powdered sauerkraut. The men are said to have had a great relish for this food, and their good health during the expedition is attributed, in great part, to the use of it.

In his address before the Congress of Orientalists, Max Müller claimed that, during the last 100 years, Oriental studies had contributed more than any other branch of scientific research to purify the intellectual atmosphere of Europe.

An exhibition of very considerable interest is to be held in Paris in September and October. It will consist of all the useful insects and their productions, and of the noxious insects, and specimens of the injury they do. Each species is to be shown, when possible, in its several stages of egg, larva, chrysalis, and perfect insect. The exhibition will be under the auspices of the Central Society of Agriculture and Entomology.

Prof. Jeffreys Wyman, of Harvard University, died at Bethlehem, N. H., September 4th, aged sixty years. The deceased was, for twenty-seven years, Hersey Professor of Anatomy at Harvard, and of Comparative Anatomy in the Lawrence Scientific School. His published works consist of numerous articles on anatomy and physiology contributed to scientific periodicals and learned societies.

The Austrian Polar Expedition, which, for some time, has caused such anxious apprehensions, has at last been heard from. The expedition was shipwrecked, and spent two winters upon the ice. The highest latitude reached was 83°. Hall's highest latitude was 82° 16′. A large tract of land was discovered northward of Nova Zembla. Only one death occurred during the whole time from the sailing of the expedition, in 1872, to their arrival at the Norwegian island of Wardoe in September of the present year.

Tissandier finds the quantity of solid matter contained in a cubic metre of Paris air to vary between 6 and 23 milligrames. Where this matter consists of *débris* of wood, coal, or the like, the corpuscles reach sometimes a length of $\frac{1}{10}$ millimetre; where of mineral matters, silica, etc., the diameter varies from $\frac{1}{100}$ to $\frac{1}{1000}$ of a millimetre. Analysis of the dust shows: organic matters, from 25 to 34 per cent.; mineral matters, from 75 to 66 per cent. Iron was found in notable quantity.

M. Gréhaut, of the Paris Biological Society, has, for some time, employed a method of producing anæsthesia by means of chloroform, which gives very satisfactory results, and produces complete anæsthesia, for any required length of time, without danger to life. To this end, he administers to the person or animal to be anæsthetized a quantity of vaporous chloroform accurately determined. He fastens to the muzzle of a dog, weighing say 20 pounds, a rubber bag holding 100 quarts of air mixed with 20 grammes (about 300 grains) of chloroform in the state of vapor. The animal breathes this confined atmosphere, and anæsthesia is produced in the course of from five to ten minutes. It may be protracted for over two hours. With this amount of chloroform the anæsthesia is complete, and, in pro-

portion as a fraction of the vapor is eliminated from the lungs, an equal quantity is absorbed by the same organ.

Silicious and calcareous rocks are more commonly broken up by chemical than by mechanical action, but the contrary is the case with felspathic and slate rocks. For subaqueous structures silicious stones are generally preferable to those of a calcareous nature.

An electro-magnetic copying-machine has been devised by Hencker, of Munich, which transmits by telegraph, and that, too, without the assistance of an operator, writing, portraits, plans, maps, etc. An impression of the object to be copied is taken with a prepared ink on a sort of silver paper, which is then rolled on a revolving cylinder, and the message, whether in writing or in the form of a drawing, is at once forwarded to its destination, a perfect fac-simile of the writing or drawing being produced at the other end of the wire.

The Paris Acclimatization Society has requested and obtained of Mr. Seth Green permission to publish a French translation of his work on trout-culture.

At Mariupal, Russia, a teacher was recently denounced to the entire parish, by the village pope, as unfit to teach children, owing to his "habit of taking walks on the steppe, and collecting useless grasses, disgusting insects, and every conceivable abomination, and making these things objects of public instruction." This wicked teacher was also censured for his disuse of the rod, and his aversion to the good old Russian practice of pulling out bunches of hair from the heads of refractory children!

The salaries of male and female teachers in the schools of San Francisco have been equalized.

An exhibition was recently made in Scotland of a process of clearing forests by steam. A traction engine of 12 horse-power is stationed some distance from the wood, and a wire chain is fastened to the tree. Steam is then put on, and the tree is pulled forcibly out by the roots. In the course of five hours, upward of 300 trees, in a plantation nearly 100 years old, were pulled out. It is hoped that the method may prove applicable in the clearing of new tracts of forest-land.

From a synopsis communicated to the Philadelphia Academy of Sciences by Prof. Cope, of his work in connection with Hayden's survey in 1873, it appears that the whole number of species of vertebrata obtained was 150, 95 being new to science. The species from the Miocene numbered 75, of which 57 were new.

A French patent has been granted for the preparation of leather from tripe, intestines, and other animal membranes; these are worked in milk-of-lime while still fresh, then washed and immersed in water, and finally in a paste made of starch and white-of-egg. The substance thus formed is to be used for glove-making, etc.; the material may also be tanned or curried.

In 1865 there were in France 4,838 school libraries containing 180,854 volumes; in 1869 the number of libraries was 14,395, and of volumes 1,239,165. At the present time there are (the Seine Department not included) 15,623 school libraries, and 1,474,637 volumes. Notwithstanding the events of the last few years, the state, provinces, communes, and private individuals, have liberally contributed funds for maintaining this important work.

The problem of pure-water supply for London has probably been solved by Mr. J. Lucas, of the Geological Survey. Examining the green sands and chalk of Surrey, he finds over 1,000 feet of porous strata resting on absolutely impervious clay. He contends that a tunnel driven along the strike of the beds, or water-level, must arrest all the water that is flowing down as far as the gallery is carried.

The question whether snakes eat toads is answered affirmatively by a writer in *Hardwicke*, who speaks from direct observation. Having discovered a garter-snake in a strawberry-bed, he struck the creature a sharp blow with a stick, and out flew a medium-sized toad. Before the blow, only the hind-feet of the toad were visible, protruding from the snake's mouth.

In removing grease-spots from clothing with benzole or turpentine, the usual way is to wet the cloth with the detergent and then to rub it with a sponge or the like. This only spreads the grease, and does not remove it. The proper method is given by the *Scientific American:* Place soft blotting-paper beneath and on top of the grease-spot, after the latter has been thoroughly saturated with the benzole; then press well. The fat is thus dissolved and absorbed by the paper, and entirely removed from the clothing.

The British Meteorological Society has organized a system of observations of natural phenomena connected with the return of the seasons, as affecting the development of animal and plant life. It is expected that in this way much valuable information will be gained with regard to the influence of climate on plants, insects, birds, and other animals. The Royal Agricultural, Horticultural, Botanical, and other societies of Great Britain, have promised their coöperation in the scheme.

A SINGULAR feature of the last illness of Guizot was, that for three weeks previous to his death his memory was totally at fault during the greater part of the day; but from noon till 5 P. M. it was quite perfect, especially if the conversation turned upon his favorite study — the history of France. Again at five he would fall into a kind of somnolence, which lasted till noon of the following day.

THE new Reclam-Siemens cremation-furnace has been tested at Berlin with satisfactory results. Two hundred weight of animal carcass was consumed in about 90 minutes, and reduced to white ashes at the cost of less than one dollar. Eighty-two German cities possess cremation societies.

FROM researches made by Phipson, it appears that thallium is much more widely distributed than has been supposed — as widely, indeed, as lead, he thinks. He has met with it especially in metallic cadmium, and the cupriferous pyrites of Spain and Norway, and in many of the other minerals and industrial products derived from them.

THE molar tooth of a mastodon was recently exhumed near Waterloo, Ind. It weighs six pounds, is eight inches long, and has four prongs and four double crowns.

THE French Minister of War, General de Cissey, has very positively prohibited the officers of the army from communicating to any scientific body, or publishing in any scientific journal, any "memoirs of a scientific character having reference to any branch of the military service. . . . Such publications," he says, "are absolutely contrary to the 'principles of (military) *hierarchy*.'" The *Revue Scientifique* naturally takes umbrage at this general order, and says that it cannot fail to do injury to the army, by placing it beyond the reach of fair criticism.

THE American Museum of Natural History in Central Park, as we learn from the *Tribune*, has lately received the Wolfe memorial gift, which consists of a collection of shells gathered by Dr. J. C. Jay, together with his library of works on conchology. The collection embraces over 10,000 species, and probably 50,000 specimens. The library is supposed to contain every book treating of shells published before 1861, and most of those issued since then. It also contains full sets of the transactions of all the prominent scientific societies.

THE Austro-Hungarian Government has decided to send out another expedition next year to ascertain whether "Franz-Josef Land" is part of the continent or an island. The expedition will be divided into two parties, one going by way of Siberia, the other by way of Greenland.

THE use of aniline red for coloring hair-oils is condemned by the *Laboratory*, and an instance is cited in proof of the injurious effects resulting from the employment of oils so colored. A man in Boston, who had for some time frequented a barber's shop in which aniline-colored oil was used in hair-dressing, began to experience a disagreeable itching of the scalp, very similar to that produced by arsenic. On inquiry, the trouble was traced to the hair-oil, which contained arsenic present in the aniline color; and, by discontinuing its use, the eruption soon disappeared.

MR. RICHARD A. PROCTOR says of our Signal-Office forecasts of the weather, that they are "singularly accurate, the percentage of error being little more than ten or twelve, and constantly diminishing." During the last three months of his stay in the United States, the weather announcements of the Signal-Office failed of strict fulfillment only twice; and even then the error consisted only in the announcement of a change in the weather a few hours before it actually occurred.

ABOUT two-thirds of the estimated cost of the Liebig Monument, at Munich, has been subscribed—the far greater part of the money coming, of course, from Germany. "England," says the *Lancet*, "numerous and deep as are her obligations to the father of agricultural chemistry, stands very low on the subscription-list, being, in fact, outstripped by Italy, which comes next, as a subscriber, to Germany itself."

A SANDSTONE anvil has been discovered near Ironton, Ohio, supposed to have been used by the mound-builders. It is composed of very sharp grit, contains over 100 depressions, weighs about 500 pounds, and measures 8 feet 8 inches at its greatest circumference. This relic of an extinct race is to be presented to the Cincinnati Society of Natural History.

IT may interest the consumers of Rhenish wines to learn that at Kehl there is a large establishment for the manufacture of wine without grapes. In the Rheingau and the Palatinate there are hundreds of similar establishments, according to the London *Times* correspondent. The Excise Bureau of the German Empire recognizes this product as grape-wine.

THE English literary journals are discussing the question of forming one English word to represent what the French call a *savant*. "Man of science" is the only expression at present in approved usage that exactly corresponds to the French word. *Scientist* is "an American barbaric trisyllable." A writer in the *Academy* gives us our choice between "sciencist" and "scient."

PROFESSOR J. LAWRENCE SMITH.